TECHNICAL SPECIFICATION

STANDARD VERTICAL TANKS
SELECTION, DESIGN AND FABRICATION

DEP 34.51.01.31-Gen.

September 1992

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP is a revision of the earlier publication of the same number and title dated December 1983. It gives the minimum technical requirements for the selection, design and fabrication of standard vertical steel storage tanks and shall be used in conjunction with requisition sheets DEP 34.51.01.93-Gen.

Design and fabrication of the tanks covered by this DEP shall also fulfil all requirements of BS 2654, except where otherwise stated.

For the erection and testing of standard vertical tanks, reference is made to DEP 64.51.01.31-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, supply/marketing installations and in onshore exploration and production facilities.

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

1.3 DEFINITIONS

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

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

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **Shall** indicates a requirement.

The word **Should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references are made, the number of the section or sub-section referred to is shown in brackets.

All publications referred to in this document are listed in (9).

Available Standard Drawings and calculations are identified in (10).

1.5 GENERAL REQUIREMENTS

1.5.1 Standard drawings

Contractor's drawings and calculations should be based on the set of Shell Standard Drawings, group S 51, for standard tanks (with their structural calculations and accessories), see (10).

Separate drawings exist for each standard diameter of tank, and for accessories, fittings, joint welding details, etc.

1.5.2 Documents required by local authorities

It is the Contractor's responsibility to make all drawings and calculations required by local authorities.

1.5.3 Approval of drawings

The Contractor shall submit the following documents to the Principal:

a. Static calculations for shell plate thicknesses, wind girders, stiffening rings, roof supporting structure, anchoring, and floating roof.

b. All design and fabrication drawings.

c. A general arrangement drawing of each tank.

   This drawing shall be to scale and shall show the position of all mountings and accessories required, with reference to the relevant detail drawings.

d. All static calculations and drawings required by local authorities.

e. A marking diagram.

If any departure from a Standard Drawing is proposed, static calculations and detail drawings clearly showing these proposed changes shall be submitted to the Principal for approval.

A separate set of documents shall be submitted to the Principal for each requisition.

1.5.4 Material certificates

Mill certificates for the materials, certifying compliance with the mechanical and chemical requirements, shall be submitted to the Principal prior to commencement of fabrication.

1.5.5 Shop inspection

Shop inspection shall be carried out in accordance with the requirements specified in the purchase order. Inspection during site erection is covered by DEP 64.51.01.31-Gen.

2. TYPES OF VERTICAL TANKS

2.1 TYPES AND RANGE OF SIZES

Standard vertical tanks are available in several types, which differ in vapour-saving efficiency and in cost. Not every type is available in the full range of diameters,

The various types of standard tanks, in order of increasing vapour-saving efficiency and the range of diameters in which each type is available, are as follows. The coding system is explained in (2.3).

2.1.1 Open top tanks (coded BOT)

This type of tank has no roof and shall not be selected for the storage of petroleum products, but may be used for fire water/cooling water.

They are available in diameters of 3 m to 78 m.

2.1.2 Fixed roof tanks

These tanks can be divided into cone roof and dome roof types and each type can be further sub-divided into non-pressure, low-pressure and high-pressure fixed roof tanks.

Non-pressure fixed roof tanks are suitable for storage at atmospheric pressure and are therefore provided with open vents.

Low-pressure fixed roof tanks are designed to work at a low internal pressure or vacuum. They are provided with pressure/vacuum breather valves set to be fully open at the design pressures.

High-pressure fixed roof tanks are designed to work at higher internal pressure or vacuum and are also fitted with pressure/vacuum breather valves set to be fully open at the design pressures. This tank type shall fulfil additional requirements to ensure its stability, see (3.2).

The assessed maximum design conditions and the standard diameters available for each type are as follows:

2.1.2.1 Cone roof tanks

	Code	Design pressure/vacuum mbar (ga)	Diameter range m
Non-pressure	BNC	7.5/2.5	3 to 60 incl.
Low-pressure	BLC	20/6.0	3 to 39 incl.
High-pressure	BHC	56/6.0	3 to 20 incl.

2.1 2.2 Dome roof tanks

	Code	Design pressure/vacuum mbar (ga)	Diameter range m
Non-pressure	BND	7.5/2.5	15 to 39 incl.
Low-pressure	BLD	20/6.0	15 to 39 incl.
High-pressure	BHD	56/6.0	15 to 20 incl.

2.1.2.3 Fixed roof tanks with floating covers

In a fixed roof tank a floating cover can be installed to give a further reduction of vapour losses. Such tanks should be designed as low-pressure tanks and be limited to a maximum diameter of 39 m.

NOTE: This is to allow the future use of pressure/vacuum (PV) valves which are required by some local/regional authorities but are not yet required by National or Industry codes such as BS 2654 or API 650.

If free vents are to be provided their number and size shall fulfill the requirements of BS 2654 Appendix E.

2.1.3 Floating roof tanks (coded BOF)

This type of tank is designed to work at atmospheric pressure.

Although normally recommended only for diameters of 15 m and greater, this does not exclude its use in smaller diameters in special circumstances. The diameter of a floating roof tank shall at least be equal to its height to enable the use of a normal rolling ladder for access to the roof.

2.2 ROOF-SUPPORTING STRUCTURES

Roof-supporting structures are related to tank diameters as indicated below:

2.2.1 Cone roof tanks

Code	Diameter range m	Roof Construction
BNC-BLC-BHC	3 to 12.5 incl.	Self-supporting cone roof with internal rafters
BNC-BLC-BHC	15 to 20 incl.	Self-supporting cone roof with internal truss framing
BNC-BLC	22 to 39 incl.	
BNC	42 to 60 incl.	

2.2.2 Dome roof tanks

Code	Diameter range m	Roof Construction
BND-BLD	15 to 39 incl.	Self-supporting dome roof with internal rafter frames
BHD	15 to 20 incl.	

In general, dome roof tanks are used only for special applications, e.g. some tanks with floating covers.

2.3 USE OF CODE SYSTEMS

All tanks in the standard range are designated by a reference code, which consists of a three-letter prefix indicating the tank type, followed by a numerical group indicating the dimensions of the tank.

The initial letter B of the prefix indicates that the shell is butt welded.

The first part of the numerical group indicates the diameter of the tank in metres, the second part indicates the height of the tank in metres.

The following letter prefixes are used to identify the standard tanks described in this specification.

BHC = High-pressure cone roof tank

BLC = Low-pressure cone roof tank

BNC = Non-pressure cone roof tank

BHD = High-pressure dome roof tank

BLD = Low-pressure dome roof tank

BND = Non-pressure dome roof tank

BOT = Open top tank

BOF = Open top tank with floating roof

Examples of the use of the code are as follows:

High-pressure cone roof tank, 15 m diameter, 12 m high	BHC 15/12
Non-pressure dome roof tank, 36 m diameter, 18 m high	BND 36/18

2.4 TYPES OF STANDARD VERTICAL TANKS

Classified according to the types and diameters of standard vertical tanks, some general data are given in the table below.

<table>
<tr><th rowspan="2"></th><th colspan="24">TANK DIAMETER IN METRES</th></tr>
<tr><th>3</th><th>4</th><th>6</th><th>8</th><th>10</th><th>12.5</th><th>15</th><th>17.5</th><th>20</th><th>22.5</th><th>25</th><th>27.5</th><th>30</th><th>33</th><th>36</th><th>39</th><th>42</th><th>45</th><th>48</th><th>54</th><th>60</th><th>66</th><th>72</th><th>78</th></tr>
<tr><td>Type of tank</td><td colspan="6">BNC, BLC, BHC, BOT</td><td colspan="3">BNC, BLC, BHC, BND, BLD, BHD, BOT, BOF</td><td colspan="7">BNC, BLC, BND, BLD,BOT, BOF</td><td colspan="3">BNC, BOT, BOF</td><td colspan="2">BOT, BOF, BNC</td><td colspan="3">BOT, BOF</td></tr>
<tr><td rowspan="10">Type of roof</td><td colspan="24">CONE ROOFS</td></tr>
<tr><td colspan="6">Radial rafters</td><td colspan="13">Internal trusses</td><td colspan="2">Internal trusses, special design</td><td colspan="3">Not available</td></tr>
<tr><td colspan="24">DOME ROOFS</td></tr>
<tr><td colspan="6">Not available</td><td colspan="10">Radial rafters</td><td colspan="8">Not available</td></tr>
<tr><td colspan="24">FLOATING ROOFS</td></tr>
<tr><td colspan="6">Under special circumstances use may be made of floating roof tanks</td><td colspan="14">Pontoon type.
Double deck type may be used only in special circumstances</td><td colspan="4">Double deck type</td></tr>
<tr><td colspan="24">FIXED ROOFS WITH FLOATING COVERS</td></tr>
<tr><td colspan="16">Under special circumstances use may be made of fixed roof tanks with floating covers. Approved types only</td><td colspan="8">Not recommended</td></tr>
<tr><td colspan="24"></td></tr>
<tr><td colspan="24"></td></tr>
<tr><td rowspan="2">Shell plates</td><td colspan="6">Minimum 1.5 m wide
Maximum 2.0 m wide*</td><td colspan="18">Minimum 2 m wide*
Maximum 3 m wide</td></tr>
<tr><td colspan="13">Bottom course minimum 8 mm thick
Remaining courses minimum 6 mm thick</td><td colspan="6">Minimum thickness 8 mm</td><td colspan="5">Minimum thickness 10 mm</td></tr>
<tr><td>Bottom plates</td><td colspan="24">Minimum thickness 6 mm</td></tr>
<tr><td>Bottom annular plates</td><td colspan="6">Thickness 8 mm</td><td colspan="18">Thickness 10, 12.5 or 15 mm, see (6.1.1)</td></tr>
</table>

* The Standard Drawings, see (10), are based on 2 m wide shell plates

3. SELECTION OF VERTICAL TANKS

3.1 GENERAL

The table below shows the types and ranges of tanks recommended for storage of different classes of petroleum products.

Although they are not dealt with in this specification, factors such as evaporation losses, pumping losses, climatic conditions, air pollution, soil conditions and local regulations shall also be taken into consideration when selecting the most suitable type(s) and size(s).

<table>
<tr><th></th><th colspan="24">TANK DIAMETER IN METRES</th></tr>
<tr><td>Class of product</td><td>3</td><td>4</td><td>6</td><td>8</td><td>10</td><td>12.5</td><td>15</td><td>17.5</td><td>20</td><td>22.5</td><td>25</td><td>27.5</td><td>30</td><td>33</td><td>36</td><td>39</td><td>42</td><td>45</td><td>48</td><td>54</td><td>60</td><td>66</td><td>72</td><td>78</td></tr>
<tr><td>Class I, flash point less than 21°C</td><td colspan="6">BHC
BLC</td><td colspan="3">BHC
BLC
BHD
BLD
BOF</td><td colspan="7">Preferably BOF
BLC
BLD</td><td colspan="3">BOF</td><td colspan="5">BOF</td></tr>
<tr><td>Class II, flash point 21°C and higher but less than 55°C</td><td colspan="6">BLC</td><td colspan="3">BLC
BLD
BOF</td><td colspan="7">Preferably BOF
BLC
BLD</td><td colspan="3">BOF
(on poor subsoils or for other special conditions BNC may be preferred)</td><td colspan="5">BOF</td></tr>
<tr><td>Class III + unclassified, flash point 55°C and higher</td><td colspan="6">BNC</td><td colspan="3">BNC
BND</td><td colspan="7">BNC
BND</td><td colspan="3">BNC</td><td colspan="2">BNC
Special cases</td><td colspan="3"></td></tr>
</table>

NOTE: Tanks up to 39 m incl., storing certain class I and II products, may be connected to a vapour recovery system, or a fixed roof with floating cover may be used (especially as an alternative to the BOF type) where rain water penetrating between shell and seal may have an adverse effect on the quality of the product stored.

3.2 STABILITY

Appendix 1 shows a world map marked with local maximum 3-second wind gust velocities, (up to 10m height). The values are approximate and should be taken only as a rough indication of the winds which may be encountered.

For calculations of tank stability in strong winds, the velocities given in the local regulations should be used; if no local regulations exist, local experience should be considered.

The standard range of tanks has been calculated to be stable in winds of up to a mean hourly wind speed of 160 km/h with the following exceptions:

- All tanks coded BHC and BHD.
- Certain tanks coded BNC, BLC, BND, BLD with diameters up to and including 15 m, as shown in Appendix 2.

Unstable tanks shall be provided with anchor bolts and concrete foundation rings. Uplift is caused by the internal vapour pressure acting against the underside of the roof, in conjunction with wind load. A stability calculation shall be made to determine the number of anchor bolts required.

For the stability calculation (overturning) of the tank a 10-second wind gust shall be assumed.

3.3 CAPACITIES

Appendix 3 lists the nominal capacities of all tanks in the standard range.

4. OPERATIONAL FITTINGS FOR VERTICAL TANKS

4.1 RANGE OF FITTINGS AND ACCESSORIES

4.1.1 Standard range

Unless otherwise specified on requisition DEP 34.51.01.93-Gen., tanks shall be provided with the standard range of fittings and accessories as listed in Appendices 4 and 5. Optional fittings shall be supplied only when specified on the requisition.

For details of standard fittings and accessories, see (10).

For very high pumping rates or in other exceptional circumstances, it may be necessary to increase the numbers or sizes of standard fittings, or to use special fittings or accessories (e.g. to carry out in-tank blending). In such instances full supporting details should be included when ordering the tank.

The numbers or sizes of fittings should not be reduced, since adherence to the specified range will simplify the procurement of fittings, reduce delivery times, facilitate the fabrication and erection of tankage and ensure interchangeability.

Fittings such as breather valves, free vents and dip hatches may be to Manufacturer's designs if these are accepted for use by the Principal.

Mountings may require adjustment to conform to the approved design of fitting.

4.1.2 Breather valves and free vents

The number and sizes of breather valves and free vents required should be specified separately due to the large variations in pumping rates, etc., see also (4.1.6). The flow capacities of the breather valves shall be based on data received from the valve Manufacturer.

The maximum flow through a breather valve, when the pallet is fully open, occurs at a pressure higher than that at which the valve pallet just commences to open, by an amount dependent on the design of the valve and the weight of the pallet. The weight shall be adjusted so that the pallet is fully open when the pressure just equals the pressure rating (i.e. 20 mbar (ga) for a low-pressure tank or 56 mbar (ga) for a high-pressure tank) or the vacuum rating (i.e. 6.0 mbar for both low-pressure and high-pressure tanks).

If the operating conditions of a tank are changed it shall be checked that the required venting capacity does not exceed the available venting capacity of the breather valves or free vents.

4.1.3 Free vents

When deciding on the number of free vents required, their capacity shall be taken at a pressure of 7.5 mbar (ga) and a vacuum of 2.5 mbar (ga).

4.1.4 Increasing heights of tanks

If the storage capacity of an existing tank is increased by fitting additional courses of shell plates, the venting capacity of the enlarged tank should be checked, and increased if necessary.

4.1.5 Roof nozzles

The flow characteristics of breather valves and free vents are influenced by the profile and length of the roof nozzle. A tapered nozzle allows a higher flow through the valve than a straight nozzle. This effect should be taken into account when calculating capacity ratings.

Wire netting in the openings of free vents and breather valves (e.g. as used to prevent nesting of birds) shall have openings of at least 6 mm square. Fine-mesh screens (e.g. as anti-flash protection) should not be used because of the danger of blockage, especially under winter conditions.

4.1.6 Required venting capacity

The venting capacity required shall be determined in accordance with the rules specified in BS 2654 or API 2000. These requirements shall be considered as minimum requirements.

The venting requirements shall include the following conditions:

- Inbreathing resulting from a maximum outflow of product from the tank.
- Inbreathing resulting from contraction of vapours caused by a maximum decrease in atmospheric temperature; see also (4.1.7).
- Outbreathing resulting from a maximum inflow of product into the tank and maximum evaporation caused by such inflow.
- Outbreathing resulting from expansion and evaporation due to a maximum increase in atmospheric temperature (thermal breathing).
- Outbreathing resulting from fire exposure.

NOTE: In addition to requirements of the current National and Industry codes (e.g. BS 2654 and API 650), both cone and dome shaped fixed roof tanks shall be designed to fail at the roof-to-shell connection when subjected to an internal explosion. This is to be considered as a primary item from a safety point of view, and is intended to eliminate further escalation such as could result from failure mode at the shell-to-bottom connection.

From detailed nonlinear dynamic finite element analyses it has been concluded that the structural concept of the present standard tank range, see (10), is likely to fail in the required manner.

4.1.7 Thermal venting

Special attention is required to the influence of a sudden drop in temperature (e.g. due to rainfall) on the venting requirements of tanks containing warm product and for tanks in tropical areas. A drop of 20 °C or more in 15 minutes may be experienced. Where these conditions apply the venting capacity shall be increased by at least 20% of the thermal venting capacity requirements.

4.2 FITTINGS COMMON TO ALL VERTICAL TANKS

4.2.1 Stairways, handrails, etc.

For the construction of stairways and handrails, see (10).

Vertical tanks should be provided with spiral stairways. An exception may be made for groups of tanks of less than 12.5 m diameter sited close together and connected by walkways at roof level. In such groups, two tanks at opposite ends of each group shall be provided with stairways, so that each tank in the group will then have at least two escape routes from the roof.

Spiral stairways should be situated on the prevailing windward side of the tank (10). The main points to be considered are as follows:

- ladders should not be used except for tanks up to 6 m high;
- permanent ladders shall not be installed inside tanks.

Handrails shall be provided at the edge of the roof for the full circumference of all fixed roof tanks, and to the centre of the roof on all tanks exceeding 12.5 m diameter. Handrails shall be provided on the outside of all spiral stairways. For open top tanks, the inside of the staircases shall also be provided with a handrail in the immediate vicinity of the top landing.

Handrails shall be provided on both sides of all walkways between tanks.

NOTE: The Principal shall specify on the requisition if it is required that all stairways and walkways are to be provided with galvanized, open grating (25 mm deep with main bearing strips of 5 mm thickness).

Stairways shall be provided with the specified lighting facilities, which shall be suitable for the area classification, see (4.2.9).

Spiral stairways for tanks with insulated shells should be adapted to suit the type of insulation used (10). Stair treads shall not penetrate the insulation.

4.2.2 Roof nozzles for breather valves, free vents, dip hatches and slot dipping devices

Fixed roof tanks shall be fitted with roof nozzles suitable for cone or dome roofs, to enable these fittings to be mounted vertically and to provide clearance when roof insulation is fitted (10).

4.2.3 Manholes

Fixed roof tanks are usually equipped with the following manholes:

Screw-down DN 508 diameter gas-tight hinged-cover roof manholes with provision for locking (10).

Bolted-cover DN 610 diameter shell manholes (10).

Except for DN 760 diameter manholes in the floating roof itself and the roof compartment manholes, floating roof tanks and open top tanks are equipped only with bolted-cover DN 610 diameter shell manholes for access into the tank.

4.2.4 Shell nozzles for inlet and outlet

The sizes of shell inlet and outlet nozzles (10) shall be specified on the requisition.
Bottom outlets may be installed only in hard foundations (e.g. rock) where soil settlements are considered negligible.

4.2.5 Drainage arrangements (centre drains or side drains)

In operation, tank bottoms should normally slope **down** towards the centre and be fitted with centre sumps; larger tanks (≥ 50 m diameter) may also be provided with additional side drain sumps, the nozzles of which may be blinded off after the watertest. However, for products with temperatures exceeding 100 °C, the tank bottom should slope **up** towards the centre in order to prevent corrosion caused by rain water penetrating under the bottom.

To achieve the desired end result, tanks may be constructed such that prior to hydrostatic testing the tank bottom slopes up towards the centre. The degree of this slope shall be determined by the anticipated settlement during and after the hydrostatic test (taking into account the soil conditions and the operational requirements for the tank concerned). Normally (product temperature ≤ 100 °C) the upward slope towards the centre shall be such that the bottom will be nearly flat after the hydrostatic test and gradually change to sloping down towards the centre during operation and further settlement. In any case the preset upward slope shall not exceed 1:120 (with a maximum peak of 300 mm) in order to reduce the possibility of bottom ripples occurring during hydrotesting.

All tanks shall be fitted with internal product drain lines of a size depending on the size of the tank and the product to be stored (10).

4.2.6 Water spray system

If specified on the requisition, a water spray system shall be supplied in accordance with DEP 80.47.10.31-Gen.

4.2.7 Foam connections

If specified on the requisition, floating roof tanks shall be equipped with a foam system in accordance with DEP 80.47.10.31-Gen.

Floating roof tanks shall be provided with a foam dam as shown on Standard Drawing S 88.009 and S 88.010.

If specified on the requisition, fixed roof tanks shall be equipped with a semi-subsurface or sub-surface foam extinguishing system in accordance with DEP 80.47.10.31-Gen.

4.2.8 Fire detection for floating roof tanks

If specified on the requisition, a detection system shall be installed in accordance with DEP 80.47.10.31-Gen.

4.2.9 Earthing bosses

All tanks shall be fitted with earthing bosses.

Classification of the tanks shall be in accordance with the IP Model Code of Safe Practice, Part 1 - Electrical Safety Code.

4.2.10 Liquid-level indicators

Liquid-level indicators or automatic liquid-level gauges shall be fitted to all tanks.

Unless otherwise specified, level indicators or automatic level gauges shall be ordered separately; however, the supplier of the tank shall include the required nozzles, gauge poles, etc. (10).

The construction of the gauge poles depends on the operational conditions and the required measurement accuracy of the level gauges. The deformation of the tank shell during filling/emptying shall be taken into account in the design of the gauge poles for tank contents subject to custody transfer.

4.2.11 Dip plates

A 6-mm thick dip plate shall be provided for welding to the tank bottom or lowest shell course directly under the dip fittings (i.e. dip hatches, slot dipping devices and combined vent and dip hatches).

4.2.12 Erection equipment

Unless otherwise specified, all tank erection equipment (e.g. key plates, carrot wedges, shims, etc.), are not considered part of the supply but shall be included in the erection contract.

If stated on the requisition, this equipment shall be supplied in accordance with the schedule of key plate erection equipment.

4.3 ADDITIONAL FITTINGS FOR FIXED ROOF TANKS

4.3.1 Class I and Class II products

Additional fittings for fixed roof tanks used for Class I and Class II products shall be as follows:

4.3.1.1 Slot dipping devices

Slot dipping devices are required for all tanks operating under pressure, so that dips and samples may be taken without excessive pressure loss (10).

4.3.1.2 Manometers or pressure/vacuum gauges

If specified, manometers shall be supplied for pressurized tanks in order that the working of the breather valves may be checked. The manometers are normally mounted at ground level for easy reading (10).

4.3.1.3 Level alarms/indication system.

At least two independent level alarm systems shall be provided:

- Low, high and high/high level alarm systems with independent transmitters for the two high levels.
- level indication system, with its own independent transmitter, should be used for normal operation.

The Hi/Hi operational product level shall be set such that the maximum filling height is limited to 200 mm below the top of the shell.

Tanks with an internal floating cover (IFC):

- the Hi/Hi level shall be set such that at least 200 mm clearance remains between any moving part of the IFC and any obstruction fixed to the shell, including the roof supporting structure.
- the Low level alarm shall be set such that the IFC still remains floating with its supports at least 100 mm above the tank bottom.

4.3.1.4 Floating suctions for tanks

A floating suction (a form of swing pipe fitted with floats to the outlet) may be provided on tanks used for storing aviation fuels. The main purpose of this fitting is to minimize the risk of extracting water-contaminated product (10).

This assembly shall never be connected to the inlet connection.

4.3.1.5 Floating covers in fixed roof tanks

Refer also to (2.1.2.3).

For safety reasons, sandwich panel type covers (which can become soaked with the product stored) shall not be used.

4.3.2 Class III + Unclassified products

Additional fittings for fixed roof tanks used for these products are as follows:

4.3.2.1 Dip hatches

Tanks shall be supplied with one dip hatch, unless additional dip hatches are required (e.g. by local regulations), in which case this shall be noted in the order.

4.3.2.2 Swing pipes and accessories

To assist in drawing off product from a variable level, tanks may be fitted with swing pipes operated by a hand winch at ground level (10).

Swing pipes shall be fitted to the outlet or service connection, never to the inlet connection.

4.3.2.3 Heating coils

If specified on the requisition, heating coils shall be fitted to tanks when products are required to be maintained at above-ambient temperatures to facilitate pumping (e.g. on lubricating oil, furnace oil, or bitumen storage tanks). In tanks where a water layer may be present on the bottom (e.g. crude oil tanks) the heating coils shall be placed sufficiently above the bottom (at least above the product/water interface) to prevent heating of the water. The heating surface shall be in accordance with the requirements specified.

4.3.2.4 Suction heaters

If specified on the requisition, suction heaters shall be provided for tanks fitted with coils when additional localized heat is required at the outlet connection. These heaters are usually of the nested tube type, and are suitable for steam or heat transfer fluid systems.

4.3.2.5 Angle ring for tank roof insulation

When tank roofs are to be insulated an additional circumferential angle ring and various small fittings shall be provided to retain the insulation material, which is terminated below the top curb angle. For the insulation, reference is made to DEP 30.46.00.31-Gen.

4.3.2.6 Side-entry mixers

Side-entry mixers may be required to improve mixing of the product or to reduce the formation of sludge, see DEP 31.51.10.31-Gen. If side-entry mixers are to be installed, the required shell connections shall be specified on the requisition. Side-entry mixers shall be placed on manhole-type shell nozzles to allow easy removal for maintenance without entering the tank.

4.3.2.7 Sample connections and thermo-indicators

If specified on the requisition, sample connections and thermo-indicators shall be provided adjacent to the spiral stairway. Such connections shall be flanged.

For the recommended numbers and sizes of fittings for this range of tanks, see Appendix 4.

4.4 SPECIAL FITTINGS AND ACCESSORIES FOR FLOATING ROOF TANKS

4.4.1 Primary roof seals

The circumferential primary roof seal may comprise metallic shoes having flexible seals with a weight or spring-operated pusher mechanism, or be a compression plate type seal, or a fabric foam filled seal.

- the lower part of the metallic shoe shall be submerged in the product;
- compression plate types shall be provided with a continuous weighted skirt which is partly submerged in the product;
- foam filled envelope seals shall be of the liquid mounted type.

Rim mounted secondary roof seals shall be used in all primary roof seal systems.

Both primary and secondary seals shall have a minimum inward and outward flexibility of 125 mm.

4.4.2 Fittings

All floating roofs shall be equipped with a complete set of accessories required for the proper functioning of the floating roof.

4.4.2.1 Supporting legs

Incorporated in the design of all floating roofs is a system of adjustable supporting legs on which the roof rests in its lowest position during operation and in its highest position during maintenance operations. Pad plates shall be located on the bottom for each supporting leg, see (6.1.4).

4.4.2.2 Roof drains

Floating roofs shall be fitted with articulated pipe drains. For pontoon-type roofs a check valve shall be provided near the roof end of the articulated pipe drain to prevent backflow of stored product onto the roof in case of leakages in jointed pipes.

Emergency drains shall not be installed in pontoon-type roofs as the oil level in the tank is always higher than the rain water level on the centre deck of the roof. The minimum size of the roof drains shall be DN 75 for tanks up to and including 20 m diameter, DN 100 for tanks over 20 m diameter and DN 150 for tanks of 60 m or more in diameter.

In areas which can experience excessive rainfall in short periods (e.g. tropical areas), two roof drains should be installed. Under normal circumstances tanks shall be operated with open roof drain valves. Flexible rubber hose drains should not be used.

4.4.2.3 Access ladder to the roof

The access ladder to the roof shall be equipped with self-levelling stair treads. The construction of the ladder wheels and the rails shall be in accordance with Standard Drawing S 51.111. The rails shall be placed at such a height above the centre deck that snow or rain water on the deck cannot affect movement of the ladder. The ladder shall be provided with an anti-derailing device to prevent uplift of the ladder during strong winds.

4.4.2.4 Earthing

In addition to the earthing bosses on the tank shell, electrical earthing facilities (spring stainless steel shunts) shall be fitted for earthing of the floating roof across the rim space at a maximum interval of 2.5 m. Their sliding contact with the shell shall be in the open air above the secondary seal. An earthing cable shall be installed along the access ladder to the roof.

4.4.2.5 Level alarms/indication system.

At least two independent level systems shall be provided:

- Low, high and high/high level alarm system with independent transmitters for the two high levels.
- level indication system, with its own independent transmitter, should be used for normal operation.

With the roof in its Hi/Hi position a free clearance of 50 mm shall still remain between moving parts of roof and seal, and any of the parts fixed to the shell.
The shunts of the roof seal shall be in contact with the shell at this roof level.

4.4.2.6 Automatic bleeder vents

Automatic bleeder vents shall be provided to vent the air from under the floating roof when the tank is being filled initially. They shall also open automatically just before the roof lands on its supports, thereby preventing the development of a vacuum under the roof. The capacity of the vents shall be based on the maximum pumping rates.

4.4.2.7 Rim vents for metallic shoe type seals

Rim vents shall be provided to prevent any excess pressure in the rim space, as this might press the shoe ring too tightly against the tank shell. Settings shall be plus and minus 2.5 mbar (ga).

4.4.2.8 Guide and level gauge pole

Unless otherwise specified on the requisition, all floating roof tanks shall be equipped with a guide pole or combined guide and level gauge pole as shown on S 51.108 or S 51.115 respectively.

4.4.2.9 Shell fittings

The shell fittings are identical to those supplied for fixed roof tanks. However, the main inlet shall be provided with an extension pipe to direct the product towards the centre of the tank (10). The nominal length inside the tank shall be D/4 (where D is the tank diameter) but shall not exceed 10 m.

4.4.2.10 Staircases - elevated gauger's platform

The staircase along the shell shall end on the top of the windgirder. A clear vertical height above the stair treads of 2000 mm shall be provided. A separate staircase shall give access to the gauger's platform, both provided with handrailing arrangements, adjusted to accommodate the roof access ladder and gauge pole assembly.

4.4.2.11 Wind girder

As the wind girder may be used as an access platform for fire fighting, its width shall not be less than 600 mm. A full perimeter railing shall be provided at the outside of the wind girder. The shape of the wind girder shall be such that a free passage of 600 mm along the supporting structure of the gauger's platform is also obtained.

4.4.3 Standard scales of fittings and accessories

For the standard scales of fittings and accessories for floating roof tanks, see Appendix 5; all roof fittings included in this appendix shall be part of the supply by the roof Manufacturer.

5. CONSTRUCTION MATERIALS

5.1 SPECIFICATIONS FOR CARBON STEEL PLATES AND SECTIONS

All steel shall be made by the basic oxygen or electric furnace process. Bessemer or rimming steels shall not be used.

Carbon steel plates and sections shall conform to the accepted standards of the countries in which the tanks are to be fabricated or the steel is to be rolled.

5.1.1 Bottom plates and roof plates

A certificate from the steel mill is required only to confirm that the steel is made according to one of the above-mentioned processes.

5.1.2 Shell plates and bottom annular plates

The steel shall contain not more than 0.23% carbon, 0.05% sulphur and 0.05% phosphorus, as determined by ladle analysis.

The steel shall have a guaranteed minimum ultimate tensile strength of at least 363 N/mm^2 and a maximum ultimate tensile strength of not more than 510 N/mm^2. The steel shall have a guaranteed yield strength of at least 206 N/mm^2. The steel shall have an elongation not less than 22%.

Mill certificates in accordance with DIN 50049 type 3.1.B shall be supplied and shall indicate the steel making process as well as the parameters stated in the material specification and this DEP.

5.2 SPECIFICATIONS FOR MEDIUM HIGH TENSILE STEEL

Medium high tensile steels may be used for the shells and bottom annular plates of medium and large storage tanks (15 000 m^3 capacity and over).

All steel shall be made by the basic oxygen or electric furnace process.

Bessemer or rimming steels shall not be used.

5.2.1 Properties of medium high tensile steel

For the purposes of this specification, steels are considered to be medium high tensile if they have a guaranteed minimum yield strength in the range of 295-355 N/mm^2 and a guaranteed ultimate tensile strength in the range of 470-620 N/mm^2.

The steel shall be fully killed and normalized to produce a fine grain structure. Semi-killed steel may be used only for plates up to 16 mm in thickness.

The ratio of yield strength to tensile strength of the plates shall not exceed 0.85.

The steel shall have an elongation of not less than 22%.

Mill certificates in accordance with DIN 50049 type 3.1.B shall be supplied and shall indicate the steel making process as well as the parameters stated in the material specification and this DEP.

5.2.2 Chemical analysis

The ladle analysis of the steel shall comply with the following requirements:

C	0.23% max.
Mn	1.50% max.
Si	0.40% max.
P	0.04% max.
S	0.04% max.
P + S	0.07% max.
V	0.10% max.
Nb	0.04% max.
Nb + V	0.10% max.

5.2.3 Carbon equivalent (for plates over 19 mm thick only)

To promote weldability, the carbon content and carbon equivalent (C_{eq}) of carbon and carbon-manganese steels to be used for storage tanks shall comply with the following:

- carbon content shall not exceed 0.23%, except for forgings and castings, where this may be relaxed to 0.25%.

In addition, one of the following carbon equivalent requirements, based on the ladle analysis, shall be satisfied:

- $$C_{eq} = C + \frac{Mn}{6} \leq 0.42\% \qquad (1)$$
- $$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \leq 0.43\% \qquad (2)$$

Formula (1) may be used if the material standard specifies C and Mn only.
Otherwise formula (2) shall be used in which case all the elements specified shall be determined per heat.

5.3 DESIGN TEMPERATURE

The lower design temperature shall be based on the climate where the tank is to be erected.
For the purpose of material selection, climates are divided into four categories ("warm", "temperate", "cold" and "very cold"). These categories are defined below, based on the LODMAT (Lowest One Day Mean Ambient Temperature).

$$\text{LODMAT} = \text{the lowest one - day value of } \left(\frac{\text{maximum temperature} + \text{minimum temperature}}{2} \right)$$

The LODMAT should be determined for the actual site if possible, from meteorological records or, if they are not available, from the best available local knowledge. Where there is any doubt, estimates should be on the safe (i.e. low temperature) side.

The liquid stored in the tank will be warmer than the LODMAT in temperate, cold and very cold climates. For this reason the design metal temperature of tanks in temperate, cold and very cold climates may be taken as respectively 5 °C, 8 °C and 10 °C higher than the bottom value of the LODMAT range.

5.3.1 Warm climates

A warm climate is a climate where the LODMAT is higher than +10 °C.

The design metal temperature of the tank shall be +10 °C.

5.3.2 Temperate climates

A temperate climate is a climate where the LODMAT is between -5 °C and +10 °C.

The design metal temperature of the tank shall be 0 °C.

5.3.3 Cold climates

A cold climate is a climate where the LODMAT is between -15 °C and -5 °C.

The design metal temperature of the tank shall be -7 °C.

5.3.4 Very cold climates

A very cold climate is a climate where the LODMAT is is between -25 °C and -15 °C.

The design metal temperature of the tank shall be -15 °C.

5.4 NOTCH TOUGHNESS FOR SHELL PLATES AND BOTTOM ANNULAR PLATES

In addition to the general specifications listed in (5.1) and (5.2), tank shell plates and bottom annular plates shall display adequate notch toughness, as shown below:

Plate thickness (mm)	Ultimate tensile strength (N/mm^2)	Minimum Charpy-V value (J)	Test temperature (°C)
≤ 12.5	IMPACT TESTS NOT REQUIRED		
> 12.5	≤ 430	27	+20 (or test temperature shown in Figure 1, whichever is lower)
> 12.5	> 430	41	-5 (or test temperature shown in Figure 1, whichever is lower)

Figure 1 shows the test temperature requirement which depends on the plate thickness and the climate of the area where the tank is to be built.

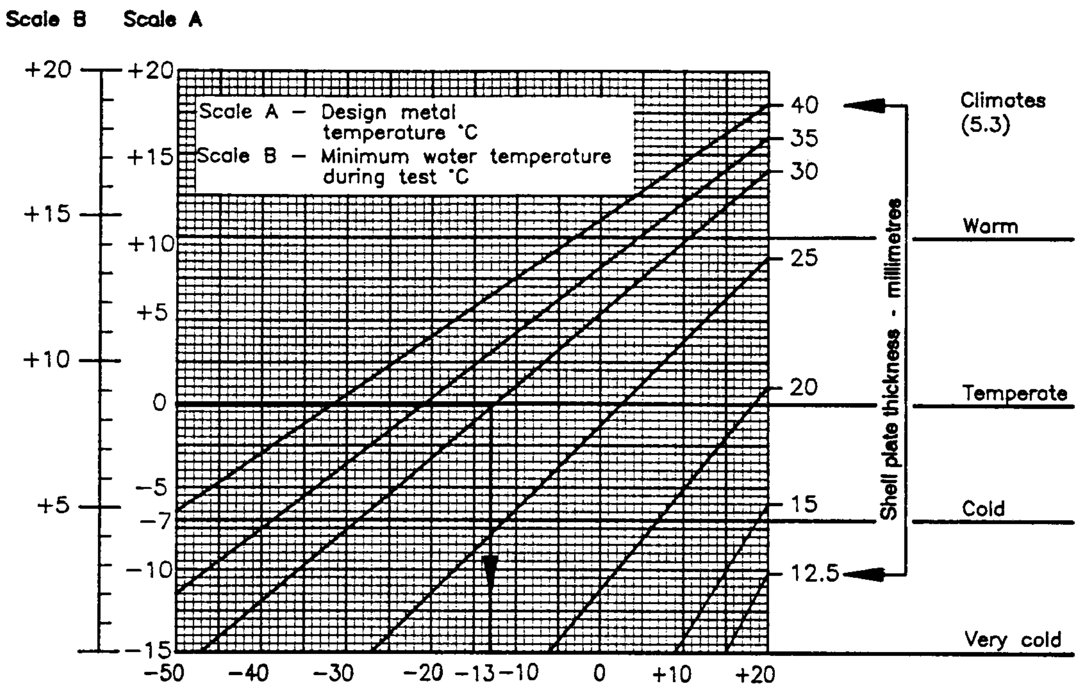


Figure 1. Charpy-V test temperature, °C

NOTES:
1. The thick horizontal lines indicate the design metal temperatures to be used in each climate.
2. Scale A is to be used for the design metal temperature of the tank and Scale B to check that the test water temperature is in line with the selected material requirement.

EXAMPLE: Suppose the plate thickness of the shell is 30 mm and the tank is located in a temperate climate: the required 27 or 41 J Charpy-V value shall be met at a test temperature of -13 °C or lower.

5.5 MECHANICAL TESTING

Mechanical testing is not required for roof and bottom plates for which the thickness is determined for practical reasons and not by stress considerations.

For shell plates and for the bottom annular plates, tests shall be made on specimens taken from each plate thickness with a frequency of one test per 25 000 kg of steel or part thereof.

5.6 MILL CERTIFICATES

Mill certificates shall show all the properties of materials guaranteed by its specification and any additional requirements. They shall be submitted to the Principal prior to commencement of fabrication.

5.7 ALLOWABLE STRESSES

The shell plates of carbon steel tanks shall be designed in accordance with one of the following design principles:

5.7.1 Simple design method for carbon steels

Allowable stress = 145 N/mm^2
Joint efficiency factor, E = 0.85

NOTE: The joint efficiency factor is the assumed ratio: $\frac{\text{weld strength}}{\text{plate strength}}$

This method shall always be used for shells where the minimum specified plate thickness is the governing factor.

5.7.2 Progressive design method for carbon steels

Allowable stress = two-thirds of the guaranteed minimum yield strength of the steel concerned

Joint efficiency factor, E = 1.00

This method shall normally be used for all tanks of 15 m and more in diameter.

The shell plates designed according to the progressive method will be thinner than those designed according to (5.7.1). When design principle (5.7.2) is used, additional requirements are specified for weld details and weld inspection; see (6.8.1) and DEP 64.51.01.31-Gen.

5.7.3 Progressive design method for medium high tensile steel

The shell plates of medium high tensile steel tanks shall be designed in accordance with the following design principle:

Allowable stress = two-thirds of the guaranteed minimum yield strength of the steel concerned

Joint efficiency factor, E = 1.00

When medium high tensile steel is used, additional requirements are specified for weld details and weld inspection; see (6.8.1) and DEP 64.51.01.31 -Gen.

5.7.4 Design for operating temperatures above 150 °C.

Allowable stress = two-thirds of the guaranteed minimum yield strength of the steel concerned, at the elevated temperature.

5.7.5 Roof structure

The maximum permissible stress to be assumed in designing roof structural members shall be in accordance with the values specified in BS 2654.

5.8 NOZZLES

All materials used for the fabrication of nozzles shall be made by the basic oxygen process. The nominal thickness of nozzles shall be as specified on the drawings.

Nozzle materials shall meet the same notch ductility requirements as those specified for the shell plates (see 5.4).

5.9 REINFORCING PLATES

Reinforcing plates shall be made from steel of the same quality as the shell plates to which they are welded.

5.10 STRUCTURAL BOLTS

Structural bolts shall have metric threads to ISO 898, grade 8.8.

5.11 FLOATING ROOF SEAL MATERIALS

The seal material for floating roof tanks shall be able to withstand contact with products having an aromatic content of 40% or less.

When a product with a higher aromatic content is to be stored, a seal material shall be chosen which will withstand contact with that product.

The Contractor or Manufacturer shall have tested the seal material sufficiently to guarantee the adequacy of the seal material for the proposed service. If required by the Principal, copies of test reports shall be made available.

6. DESIGN

6.1 BOTTOM DESIGN

6.1.1 Plate thickness

Tanks up to and including 12.5 m diameter:
Bottom plates shall be at least 6 mm thick and bottom annular plates shall be at least 8 mm thick.

Tanks exceeding 12.5 m diameter:
Bottom plates shall be at least 6 mm thick. The minimum thickness of bottom annular plates depends on the design method used and the thickness of the lowest shell course, and shall be as shown in the table below:

Design Method	Thickness of first (lowest) shell course (mm)	Required minimum thickness of bottom annular plate (mm)
Simple (5.7.1)	< 25 ≥ 25	10 12.5
Progressive (5.7.2, 5.7.3)	≤ 19 19 - 35 > 35	10 12.5 15

The bottom annular plates shall have a minimum width of 600 mm at any point.

6.1.2 Attachment to shell plates

The connection between the bottom edge of the lowest course of shell plates and the bottom annular plates shall be a continuous fillet weld on both sides of the shell plates.

6.1 3 Joints in tank bottom plates

All joints in bottom plates shall be lapped. The minimum lap shall be five times the thickness of the plate.

There shall be a minimum lap of 65 mm between the bottom plates and the bottom annular plates.

The radial seams connecting the ends of the bottom annular plates shall be butt welded using a 5 mm thick backing strip to achieve full penetration of the weld.

6.1.4 Pad plates

Pad plates fixed to the tank bottom shall be used at all supports. Pad plates should be of circular shape; if square or rectangular plates are used, they shall have their corners rounded (radius at least 5 times the plate thickness) and continuously welded.

6.2 SHELL DESIGN

Design calculations for shell plates shall take the following into account:

1. The maximum allowable tensile stress in the shell plates, before applying factor E for the efficiency of the joint, shall be in accordance with the values given in (5.7).
2. In calculating the required plate thickness, the joint efficiency factor E shall be taken as 0.85 or 1.00 depending on the design principle, see (5.7).

6.3 LIMITS FOR SHELL PLATE THICKNESS

The bottom course shall have a minimum height of 1500 mm and a minimum thickness of 8 mm.

The nominal thickness of the shell plates shall not exceed 40 mm. The minimum shell thickness shall be 6 mm for tanks of less than 33 m in diameter, 8 mm for tanks of 33 m up to and including 60 m in diameter, and 10 mm for tanks over 60 m in diameter.

6.4 INTERNAL LOADING

Internal loading stresses on the tank shall be calculated as follows:

The minimum thickness (t) of the tank shell shall be calculated on the assumption that the tank is filled to its full cylindrical height with water. The tensile stress in each course shall be calculated at 300 mm above the lower edge of the plate under consideration.

The following formula shall be used in calculating the required thickness of shell plates:

$$t = \frac{D}{20SE}\left(98w\,(H - 0.3) + p\right) + c \qquad \text{mm}$$

in which:

S = maximum allowable design stress in N/mm^2 (see 5.7)
E = joint efficiency factor
H = height from the lower edge of the course under consideration to the top of the shell in metres
D = nominal diameter of tank in metres
p = design pressure in mbar (ga)
c = corrosion allowance in mm (for special cases only, to be specified in requisition; normally zero)
w = maximum density of product to be stored in g/ml (a value of 1.00 shall be used even where the product to be stored is lighter)

No course shall have a thickness less than that of the course above, regardless of the material of construction.

The shell plates for which a minimum thickness has been calculated shall be ordered to such a thickness that it is ensured that the plates furnished by the mill will not underrun the computed thickness by more than 0.25 mm at any place.

6.5 EXTERNAL LOADING

6.5.1 Primary wind girders

6.5.1.1 Open top and floating roof tanks.

Open top and floating roof tanks shall be provided with a primary wind girder to maintain roundness when the tank is subjected to wind loads. The wind girder shall be in the form of a ring located on the outside of the tank shell, approximately 1 m below the top of the uppermost shell course. The top of the uppermost shell course shall be provided with a top curb angle.

6.5.1.2 Section modulus of primary wind girders

The required minimum section modulus of the wind girder shall be determined by the following formula:

Section modulus $Z = 58\ D^2\ H$ (mm^3)

where: D = nominal diameter of the tank in metres (with a maximum of 60 m for tanks in excess of 60 m diameter).

and H = height of tank shell in metres, including (for floating roof tanks) any freeboard provided above the maximum filling height as a guide for the floating roof.

This formula is valid for areas where at the 10 m level the 3-second gust design wind speed (V) is less than 45 m/s. For higher wind speeds the section modulus shall be multiplied by the ratio

$$\left(\frac{V}{45}\right)^2$$

where: V = highest wind speed that may occur (m/s).

6.5.1.3 Construction of primary wind girders

Wind girders may be constructed either from structural sections, formed plate sections, sections built up by welding, or from any combination of the preceding types assembled by welding. The outer periphery of the wind girder may be either circular or polygonal.

Girders of such design that rain water may become trapped shall be provided with adequate drain holes. All wind girders shall have a downward slope to the outside of 1:50.

Supports shall be provided for all wind girders when the width of the horizontal leg or web exceeds 16 times the thickness of the leg or web.

The supports shall be placed at such intervals as may be required to carry the dead load and any vertical live loads which may be placed on the ring. The spacing shall not exceed 24 times the width of the outside compression flange.

Continuous welds shall be used for all joints in wind girders. Full penetration butt welds shall be used for joining sections of the wind girder ring.

6.5.2 Secondary wind girders

6.5.2.1 General

Tanks may require secondary rings to maintain roundness over the full height of the tank shell under wind and/or vacuum conditions. The need for these secondary rings and the required number shall be calculated as indicated in BS 2654.

The wind speed used in the calculation shall be the 3-second gust design wind speed (refer to DEP 34.00.01.30-Gen.).

6.5.2.2 Location of secondary wind girders

The stiffeners on the shell shall be located in accordance with BS 2654.

In view of possible corrosion, which often occurs at the upper part of the tank shell, the stiffeners should be installed as high as permitted by the calculation results.

6.5.2.3 Design of secondary wind girders

The minimum sizing for additional stiffening rings shall be as follows:

Diameter of tank in metres	Angle or equivalent section modulus
D≤ 20	100 x 65 x 8 mm
20 < D ≤ 36	125 x 75 x 8 mm
36 < D ≤ 48	150 x 90 x 10 mm
D > 48	200 x 100 x 12 mm

Continuous welds shall be used for all connections of secondary wind girders. Full penetration butt welds shall be used for joining sections of the wind girder ring. A mouse hole (20 mm radius) shall be made in the joining sections next to the tank shell to prevent fusion between butt weld and tank shell.

6.5.3 Isolated radial loads

Isolated radial loads on the tank shell, such as those caused by the weight of heavy platforms or elevated walkways between tanks, shall be distributed along the shell by rolled structural section, plate ribs or built-up members, preferably in a horizontal position.

6.5.4 Earthquakes

The Principal shall identify whether BS 2654, Appendix G applies, or whether in view of the high seismic activity of the area, additional calculations will be required.

In the former case, the Principal shall provide the applicable lateral force coefficient.

In the latter case, the Principal shall identify the applicable OBE (Operating Basis Earthquake) and SSE (Safe Shutdown Earthquake) return frequencies. Basic design assumptions and the design method are subject to approval of the Principal.

6.6 SHELL PLATE ARRANGEMENT

The diameter on the centre line of each course shall be equal to the nominal diameter of the tank.

The vertical joints between shell plates shall not be in alignment within any three consecutive courses, and the distance between vertical joints in adjacent courses shall be approximately one-third of the plate length. If this is not possible, the distance between vertical joints in adjacent courses shall not be less than 0.3 m.

6.7 TOP CURB ANGLE

The uppermost shell course of fixed roof tanks shall be provided with a top curb angle of suitable dimensions as specified on the Standard Drawings. The angle shall be attached to the upper edge of the shell plates by a continuous double square butt joint or a double lap joint (10).

6.8 SHELL OPENINGS

6.8.1 Reinforcement of shell openings

All openings larger than 80 mm in diameter shall be reinforced. The cross sectional area of the reinforcement shall not be less than 0.75 of the product of the vertical diameter of the hole cut in the tank and the thickness of the shell plate (i.e. 75% reinforcement as identified in BS 2654). The cross-sectional area of the reinforcement shall be measured vertically in line with the vertical diameter of the opening.

All opening connections (such as nozzles and manholes) in shell plates designed in accordance with methods (5.7.2) and (5.7.3) shall be attached by welds fully penetrating the shell plate.

All opening connections 300 mm or larger in diameter in carbon steel shell plates exceeding 25 mm in thickness, designed in accordance with method (5.7.2), shall be prefabricated into the shell plate and be thermally stress-relieved thereafter.

All opening connections 100 mm or larger in diameter in medium high tensile steel shell plates exceeding 20 mm in thickness, designed in accordance with method (5.7.3), shall be prefabricated into the shell plate and be thermally stress relieved thereafter.

The above stress reliefs shall be performed at a temperature of 580-620 °C for one hour per 25 mm of shell plate thickness. Reports of the stress relieving in the form of temperature/time graphs shall be made available to Principal.

Magnetic particle inspection in accordance with BS 6072 shall be performed on the welds of all opening connections in carbon steel plates over 20 mm thick or in medium high tensile steel plates of all thicknesses. This inspection shall be performed before the hydrostatic test.

For details of reinforcement required for standard fittings, see (10).

NOTE: For the purposes of prefabrication and stress relieving of nozzles, it is essential that the final nozzle orientation drawing is available as soon as possible after placement of the order.

6.8.2 Pipe connections

Pipes connected to the nozzles of tank shells designed in accordance with method (5.7.3) shall be designed in such a way that no significant bending moments or loads act on the nozzle. The settlement of the tank, the outward movement of the shell and the inclination of the nozzle under full hydrostatic load shall be taken into account. For nozzles DN 500 and more in diameter the use of bellows and balanced supports should be considered. Large-size shell nozzle connections (e.g. > DN 500 in diameter) may influence the lowest position of the floating roof and increase the 'dead stock'. In such a case two smaller shell nozzles should be used in order to reduce the 'dead stock'.

6.8.3 Clean-out doors

If required for tanks made of carbon steel, clean-out doors shall be designed and fabricated in accordance with BS 2654.

Flush-type clean-out doors shall not be used for tanks made of medium high tensile steel. If sludge removal is expected to be required in the future, additional shell manholes DN 760 or DN 915 in accordance with API 650 shall be provided, which allow the entry of a conveyer belt, if required.

6.9 FIXED ROOF DESIGNS

6.9.1 Type of roof

Fixed roofs shall be of the self-supporting type, i.e. the roof structure shall be such that all roof loads are carried entirely on the periphery of the tank.

6.9.2 Design loads

Roofs shall be designed to withstand the following loads and internal vacuums.

For tanks up to and including 39 m in diameter, a total design load of 1940 N/m^2 measured in a horizontal plane, made up as follows:

	N/m^2
Load due to weight of roof sheets and framing	740
Live load and vacuum	1200

Total	1940

For tanks exceeding 39 m and up to and incl. 60 m in diameter, a total design load of 2080 N/m2 measured in a horizontal plane, made up as follows:

	N/m^2
Load due to weight of roof sheets and framing	880
Live load and vacuum	1200

Total	2080

In addition, the roof structure and top curb shall be designed to withstand the following internal pressures:

For high-pressure tanks (coded BHC and BHD):	a design pressure of 56 mbar (ga).
For low-pressure tanks (coded BLC and BLD):	a design pressure of 20 mbar (ga).
For non-pressure tanks (coded BNC and BND):	a design pressure of 7.5 mbar (ga).

6.9.3 Design of supporting structure

The arrangement of the roof-supporting structure for tanks of each diameter shall be as shown on the Standard Drawings (10).

The structures shall be designed in accordance with the allowable stresses and design procedure given in (5.7).

6.9.4 Supporting of roof plates

Cone roofs shall be shaped to the surface of a right cone, with a radius to height ratio of 5.

Dome roofs shall be shaped to a spherical surface, with a radius of curvature 1.5 times the diameter of the tank.

6.9.5 Roof plates

6.9.5.1 Tanks up to 12.5 m diameter

The roof plates of tanks less than 8 m in diameter shall be radial in shape. Roof plates for tanks between 8 and 12.5 m in diameter may be either radial or rectangular in shape.

6.9.5.2 Tanks 15 m diameter and larger

The roof plates of tanks 15 m in diameter and larger shall be of rectangular shape. On tanks less than 30 m in diameter the rectangular plates shall be connected to the top curb angle by sketch plates. For cone roof tanks of 30 m diameter and larger an outer ring of segmental annular plates (1000 mm minimum width, 6mm nominal thickness) shall be used.

6.9.5.3 Joining of plates

Laps shall be arranged with the higher plates (i.e. those nearer the tank centre) underneath the lower plates, in order to avoid the risk of condensed moisture becoming trapped in the lap on the underside of the roof.

6.9.5.4 Supporting of roof plates

Roof plates shall not be attached to the roof-supporting structure. They shall be continuously fillet-welded (seal weld) to the top curb angle with a maximum throat thickness as follows:

3 mm for tanks ≤ 12.5 m diameter
5 mm for tanks > 12.5 m diameter

6.9.6 Spacing of roof members

For cone roofs, the spacing of roof purlins shall not exceed 1.92 m at the periphery.
For dome roofs, the spacing of rafters shall not exceed 2.88 m at the periphery.

6.10 FLOATING ROOF DESIGNS

6.10.1 General

Single deck, pontoon type or double deck designs of floating roofs are normally used, but other designs may be used if accepted by the Principal.

For tanks with a diameter of 50 m and larger, double deck type floating roofs should be used, particularly in areas with strong wind gusts. As the airspace in the double deck provides an insulation layer, this roof type should also be used for high pour point crude oils in temperate, cold and very cold climates, and for very light products in warm climates.

The Contractor shall submit calculations of the roof showing that the roof fulfils the buoyancy and strength requirements for the conditions specified in BS 2654.

The floating roof and its accessories shall be made in such a manner that the dead stock in the tank, at the lowest position of the roof, will be minimized. If specified on the requisition a wind skirt shall be placed on top of the shell to increase the net capacity of the tank.

The design of floating roofs is not covered in this DEP since floating roofs are generally Contractor's standard designs. However, all drawings and calculations are required and shall be sent for approval to the Principal (1.5.3).

7. DESIGN OF FITTINGS, MOUNTINGS AND ACCESSORIES

7.1 GENERAL

Tanks shall be provided with fittings and mountings as specified on the requisition.

All tank fittings and mountings shall be in accordance with the standard detail drawings (10) and any additional requirements specified.

7.2 FLANGE DRILLING

The flanges for all mountings up to and including DN 600 nominal pipe size except shell and roof manholes shall be made and drilled in accordance with BS 1560 or ANSI B16.5.

Flanges for nominal pipe sizes over DN 600 shall be made and drilled in accordance with MSS SP-44.

7.3 STAIRWAYS AND WALKWAYS

Stairways and walkways shall be designed in accordance with Standard Drawings S 51.087 and S 51.053 and/or S 51.054.

Stairways and walkways shall be made of carbon steel.

The minimum clear walking space on stairways and walkways shall be 600 mm.

The angle of stairways to the horizontal plane shall be 45°.

Stairway treads shall be of the raised pattern non-slip plate type. When galvanized open type grating is required, it shall be specified on the requisition. Stairs shall have a rise of 200 mm and treads shall have a minimum width of 200 mm measured at the middle of the tread.

Spiral stairways shall be completely supported by the tank shell, and the ends of any stringers or supports shall terminate clear of the tank foundation. Stair treads shall not be welded directly to medium high tensile steel shells having a thickness of more than 12.5 mm.

Stairways and walkways shall be capable of supporting a superimposed live load of 2 kN/m^2 or a concentrated load of 3 kN applied at any point.

Walkways which extend from one tank to another tank or structure, or to the ground, shall be supported in such a way as to permit free movement of the structures joined by the walkway, relative to each other and to the ground.

Rolling ladders for access to floating roofs shall be equipped with self-levelling treads. The wheels shall be provided with ball bearings, see Standard Drawing S 51.111.

7.4 HANDRAILS

Handrails on tank roofs, stairways and walkways shall be designed in accordance with Standard Drawings, see (10). The following requirements shall apply:

- Handrails shall be constructed from carbon steel angles.
- The distance between handrail uprights around the tank perimeter, on walkways, or along the slope of stairways shall not exceed 2.4 m.
- Handrails shall be provided on both sides of walkways and straight stairways, and also on both sides of circumferential spiral stairways if the distance between the inner stringer and the tank exceeds 200 mm.
- On all handrails the top rail and all uprights shall be capable of withstanding a load of 0.5 kN applied at any point and in any direction.

7.5 VERTICAL LADDERS

Fixed vertical ladders shall be constructed of carbon steel and shall be completely supported by the tank shell, with the ends of the runners terminating clear of the tank foundation.

Ladders exceeding 4.0 m in length shall be provided with safety cages, see (10).

8. FABRICATION

8.1 TANK PARTS

8.1.1 Plate edge preparation

8.1.1.1 General

The edges of plates may be sheared, machined, or cut with a machine-operated gas torch. Shearing shall be limited to plates 10 mm or less in thickness.

When the edges of plates are cut with a torch the resulting surface shall be uniform and smooth and shall be free from scale and slag accumulations before welding. A remaining fine film of rust adhering to cut or sheared edges after wire brushing need not be removed before welding.

Curved edges of roof and bottom sketch plates and bottom annular plates shall be cut to shape in the workshop by mechanized gas cutting or machining.

8.1.1.2 Plate edge joints for shell plates

Recommended plate edge joints for hand welding are as follows:

1. Vertical joints

   Open-gap square butt joints may be used only for plate thicknesses of 6 mm.

   Single-vee butt joints shall not be used for plate thicknesses exceeding 13 mm.

   Double-vee butt joints shall not be used for plate thicknesses ≤ 8 mm and shall be used for plate thicknesses over 13 mm.

2. Horizontal joints

   Open-gap square butt joints may be used only where the thickness of the thinner plate does not exceed 8 mm.

   Single-bevel butt joints may be used for plate thicknesses up to 8 mm and shall be used where the thickness of the thinner plate exceeds 8 mm but does not exceed 13 mm.

   Double-bevel butt joints may be used for plate thicknesses over 6 mm and shall be used for plate thicknesses exceeding 13 mm.

   For details of the above-mentioned acceptable forms of joints, see (10).

8.1.2 Tolerances

The profile of all shell plates shall be accurate within a tolerance of ± 2 mm in length

and ± 1 mm in width. In addition, to ensure that plates are truly rectangular, the length of the diagonals measured across the rectangle formed by scribing lines 50 mm from each edge shall not differ by more than 3 mm.

8.1.3 Rolling and pressing

All shell plates shall be rolled to the correct tank curvature. Shell plates for tanks smaller than 25 m diameter shall have their ends pre-set to the proper curvature.

8.1 4 Workshop assembly

If pre-assembly is specified on the requisition, the structure or part thereof shall be laid out on the works floor for inspection by the Principal.

When tanks are made to new templates, the roof of the first tank of each diameter made shall be fully assembled complete with top curb angles and top course shell plates, to prove the standard templates. Roofs of the same diameter made subsequently from the same templates need not be erected in the workshop.

8.2 WELDING

All welding of tank plates, steel framing, structural attachments and mountings shall be carried out by welders in accordance with welding procedures, both qualified in accordance with BS 4870/4871 or ASME IX. Welding procedures shall be qualified with the same notch ductility requirements as those required for shell plates (see 5.4).

All horizontal and vertical welds in shell plates shall have full penetration and complete fusion and shall meet the requirements of DEP 64.51.01.31-Gen.

8.2.1 Bottom plate joints

All lap joints shall be fully fillet welded on the top side only. If a full fillet weld cannot be achieved in one pass, the fillet weld shall be made in two passes.

8.2.2 Bottom to shell plate joint

The lower shell plates shall be connected to the bottom annular plates by continuous fillet welds on both sides.

The leg length of both fillet welds shall be equal to the thickness of the bottom annular plates, except when the shell plate thickness is less than the bottom annular plate thickness, in which case the leg length of each fillet weld shall not exceed the thickness of the shell plate by more than 1.5 mm.

8.2.3 Shell butt joints

Shell butt joints shall be made as follows:

All seams shall be butt-welded from both sides of the plate.

In single-vee or single-bevel butt joints, the vee or bevel shall be made on the outside of the tank, unless otherwise agreed by the Principal.

8.2.4 Automatic welding

Automatic welding may be used by the erection contractor, subject to approval by the Principal. When automatic welding is used, details of plate edge preparation will be specified by the erection contractor. Single-pass automatic welding of vertical shell seams may be proposed only for warm climates (as defined in 5.3.1). For automatic welding of vertical shell seams, additional ultrasonic inspection shall be required. See DEP 64.51.01.31-Gen.

8.3 SHOP-WELDED TANKS

Tanks which are fully shop-welded shall be provided with lugs for lifting the entire tank by crane.

8.4 WORKSHOP SURFACE TREATMENT AND PAINTING

The requisition shall state which surface treatment and workshop painting is required for each individual tank.

The painting shall be in accordance with DEP 30.48.00.31-Gen. unless specifically stated otherwise.

8.5 HOLDING-DOWN BOLTS

If holding-down bolts are included in the supply, they shall be fabricated as soon as possible after approval of the relevant drawing by the Principal and be despatched to the delivery point as defined in the order.

Holding-down bolts are to be derusted and degreased only. The threads of the bolts and nuts shall be oiled at installation.

9. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Index to standard drawings	DEP 00.00.06.06-Gen.
Thermal insulation for hot services	DEP 30.46.00.31-Gen.
Painting and coating for new construction projects	DEP 30.48.00.31-Gen.
Side-entry mixers for storage tanks	DEP 31.51.10.31-Gen.
Minimum requirements for structural design and engineering	DEP 34.00.01.30-Gen.
Requisition for storage tanks	DEP 34.51.01.93-Gen.
Erection and testing of standard vertical tanks	DEP 64.51.01.31-Gen.
Fire protection systems and equipment	DEP 80.47.10.31-Gen.

AMERICAN STANDARDS

Pipe flanges and flanged fittings — ANSI B16.5

Issued by:
American National Standards Institute,
1430 Broadway, New York, NY 10018,
Broadway, New York, NY 10018,
USA

Welded steel tanks for oil storage — API 650

Venting atmospheric and low-pressure storage tanks — API 2000

Issued by:
American Petroleum Institute,
Publications and Distribution Section,
2101 L Street Northwest,
Washington, DC 20037, USA

Boiler and pressure vessel code:
Section IX - Welding and brazing qualification — ASME IX

Issued by:
American Society of Mechanical Engineers,
345 East 47th Street,
New York NY 10017,
USA.

Steel pipe line flanges — MSS SP-44

Issued by:
Manufacturers Standardization Society,
5203 Leesburg Pike, Suite 502,
Falls Church, Virginia 22041, USA

BRITISH STANDARDS

Steel pipe flanges and flanged fittings	BS 1560
Vertical steel welded storage tanks with butt-welded shells for the petroleum industry	BS 2654
Specification for approval testing of welding procedures	BS 4870
Specification for approval testing of welders working to approved welding procedures	BS 4871

Issued by:
British Standards Institution,
2 Park Street, London W1A 2BS,
England

IP Model Code of Safe Practice	Part 1 - Electrical Safety Code

Issued by:
Institute of Petroleum,
61 New Cavendish Street,
London W1M 8AR, England

GERMAN STANDARDS

Certificates of materials testing	DIN 50049

Issued by:
Beuth Verlag GmbH,
Burggrafenstrasze 4 - 10,
1000 Berlin 30,
Germany.

10. STANDARD DRAWINGS AND CALCULATIONS

In this DEP reference is made to the following Standard Drawings:

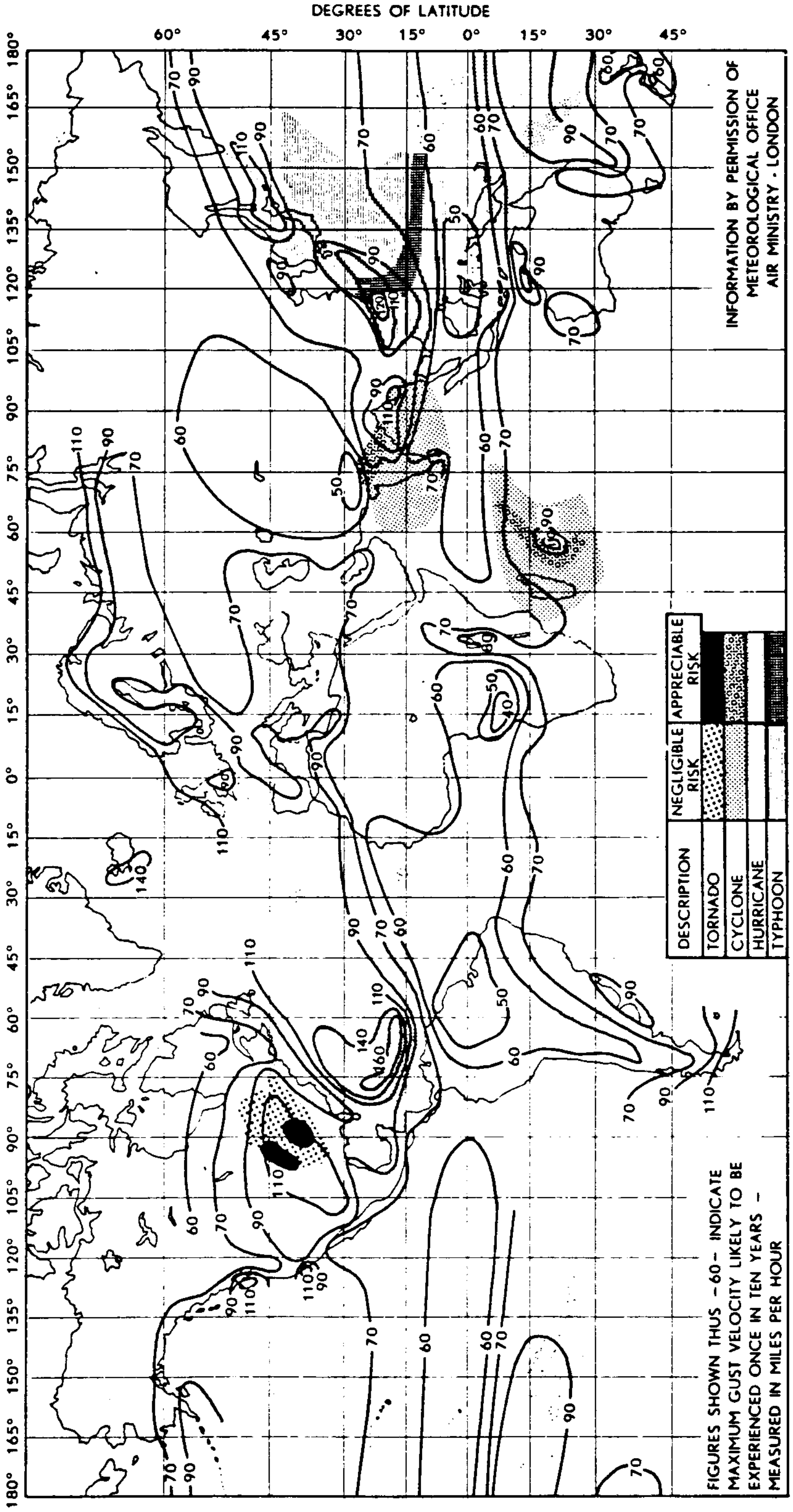
NOTES: 1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto. The latest edition of each Standard Drawing can be found in the index DEP 00.00.06.06-Gen., as can the full list of Group S51 Standard Drawings.

2. The requisition shall indicate the applicable Standard Drawings

Group 51 - Storage Tanks, Spheres and Accessories	S51.XXX
Details of spiral-type staircase	S 51.053
Details of spiral staircase for tank with insulated shell	S 51.054
Spiral type staircase provided with stair treads of galvanised grating	S 51.087
8" slotted guide pole/sampling pole for floating roof tank	S 51.108
Wheel and rail track assembly for ladder to floating roof tank	S 51.111
Guide and level gauge pole for floating roof tanks (for custody transfer)	S 51.115
Foam pourer for floating roof tank	S 88.009
Foam pourers for floating roof tanks	S 88.010

APPENDICES

APPENDIX 1 WORLD MAP SHOWING STRONG WIND AREAS AND MAXIMUM GUST VELOCITIES

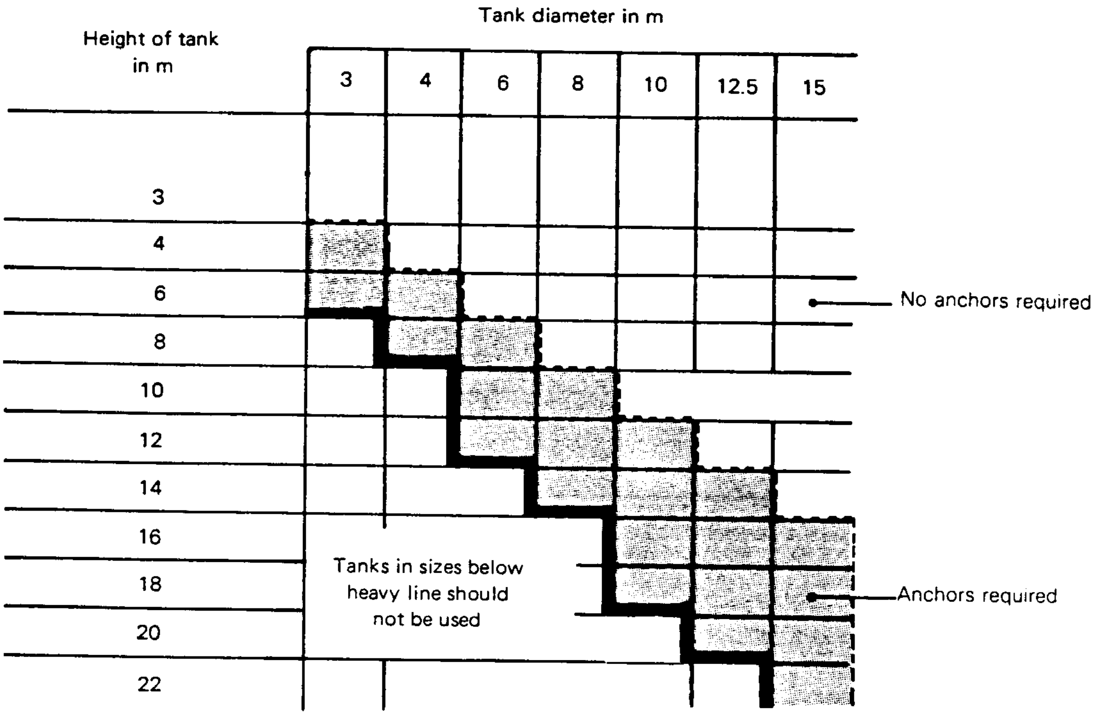


Note: The maximum wind values shown on the chart are approximate 3 sec. gusts at 10m height and should be accepted only as a rough indication of the winds which may be encountered. For calculations of tank stability in strong winds, the velocities given in the local regulations should be used. If no local regulations exist, local experience should be taken into account.

APPENDIX 2 DETERMINATION OF TANK STABILITY IN STRONG WINDS

Stability calculation based on:
- a mean hourly wind speed of 160 km/h
- 10-second gust factor
- category 2 *)

*) Refer to DEP 34.00.01.30-Gen.



NOTES:

1. As a rough indication it may be assumed that BNC, BLC, BND and BLD tanks in sizes above the dotted line are stable in winds less than 160 km/h if at least 0.5 m of product is present in the tank.

   BNC, BLC, BND and BLD tanks in sizes within the shaded area are unstable in winds of 160 km/h and require anchoring.

2. Tanks coded BHC and BHD shall always be fitted with brackets to provide holding down anchors.

3. Detailed stability calculations shall be made to determine whether a tank of a certain size is stable for a specified wind speed. See (3.2).

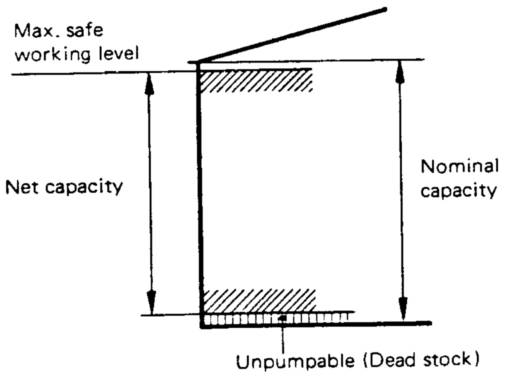
APPENDIX 3 DIAMETERS AND NOMINAL CAPACITIES FOR STANDARD VERTICAL CYLINDRICAL TANKS

In this appendix the capacities are shown for a standard range of diameters. These diameters are based on the application of the following standard lengths for shell plates:

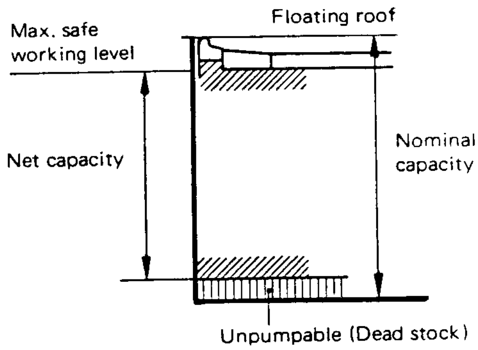
Tank diameter (m)	Shell plate length (m)
3	1.5 π
4 to 10	2.0 π
12.5 to 30	2.5 π
33 to 78	3.0 π

These standard plate lengths are selected in accordance with plate lengths generally used in Europe. The heights have not been standardized and the table on page 2 of this appendix shows capacities for every metre of tank height.
For a given tank height the Contractor may choose the number of courses and the plate widths to obtain the most economical solution. It is strongly recommended that the standard diameters given in this appendix should be used. This standardization will reduce the possibility of errors in design, fabrication and erection as well as the time required for approval of design drawings by the Principal and authorities. For diameters 3 to 60 m incl., Standard Drawings (S51.xxx) of fixed, self-supporting, cone roofs are available, see (10).

Fixed roof tanks



Floating roof tanks



APPENDIX 3 (continued) DIAMETERS AND NOMINAL CAPACITIES FOR STANDARD VERTICAL CYLINDRICAL TANKS

Height in m	Tank diameter in m: 3	4	6	8	10	12.5	15	17.5	20	22.5	25	27.5	30	33	36	39	42	45	48	54	60	66	72	78
	Nominal capacities in m^3																							
1	7	12	28	50	78	122	176	240	314	397	490	593	706	855	1017	1194	1385	1590	1809	2290	2827	3421	4071	4778
2	14	25	56	100	157	245	353	481	628	795	981	1187	1413	1710	2035	2389	2770	3180	3619	4580	5654	6842	8142	9556
3	21	37	84	150	235	358	530	721	942	1192	1472	1781	2120	2565	3053	3583	4156	4771	5428	6870	8482	10263	12214	14335
4	28	50	113	201	314	490	706	962	1256	1590	1963	2375	2827	3421	4071	4778	5541	6361	7238	9160	11309	13684	16285	19113
5	35	62	141	251	392	613	883	1202	1570	1988	2454	2969	3534	4276	5089	5972	6927	7952	9047	11451	14137	17105	20357	23891
6	42	75	169	301	471	736	1060	1443	1884	2385	2945	3563	4241	5131	6107	7167	8312	9542	10857	13741	16964	20527	24428	28670
7		87	197	351	549	859	1237	1683	2199	2783	3436	4157	4948	5987	7125	8362	9698	11133	12666	16031	19792	23948	28500	33448
8		100	226	402	628	981	1413	1924	2513	3180	3926	4751	5654	6842	8142	9556	11083	12723	14476	18321	22619	27369	32571	38226
9			254	452	706	1104	1590	2164	2827	3578	4417	5345	6361	7697	9160	10751	12468	14313	16285	20611	25446	30790	36643	43005
10			282	502	785	1227	1767	2405	3141	3976	4908	5939	7068	8552	10178	11945	13854	15904	18095	22902	28274	34211	40714	47783
11				552	863	1349	1943	2645	3455	4373	5399	6533	7775	9408	11196	13140	15239	17494	19905	25192	31101	37633	44786	52561
12				603	942	1472	2120	2886	3769	4771	5890	7127	8482	10263	12214	14335	16625	19085	21714	27482	33929	41054	48857	57340
13					1021	1595	2297	3126	4084	5168	6381	7721	9189	11118	13232	15529	18010	20675	23524	29772	36756	44475	52929	62118
14					1099	1718	2474	3367	4398	5566	6872	8315	9896	11974	14250	16724	19396	22266	25333	32063	39584	47896	57000	66896
15					1178	1840	2650	3607	4712	5964	7363	8909	10602	12829	15268	17918	20781	23856	27143	34353	42411	51317	61072	71675
16					1256	1963	2827	3848	5026	6361	7853	9503	11309	13684	16285	19113	22167	25446	28952	36643	45238	54739	65143	76453
17						2086	3004	4088	5340	6759	8344	10097	12016	14540	17303	20308	23552	27037	30762	38933	48066	58160	69215	81232
18						2208	3180	4329	5654	7156	8835	10691	12723	15395	18321	21502	24937	28627	32571	41223	50893	61581	73286	86010
19						2331	3357	4570	5969	7554	9326	11285	13430	16250	19339	22697	26323	30218	34381	43514	53721	65002	77358	90788
20						2454	3534	4810	6283	7952	9817	11879	14137	17105	20357	23891	27708	31808	36191	45804	56548	68423	81429	95567
21							3711	5051	6597	8349	10308	12473	14844	17961	21375	25086	29094	33399	38000	48094	59376	71844	85501	100345
22							3887	5291	6911	8747	10799	13067	15550	18816	22393	26280	30479	34989	39810	50384	62203	75266	89572	105123

NOTES:
1. Nominal capacities of tanks are calculated on the assumption that the tank has a flat bottom and is filled to the top of the shell plates.
2. The net capacity of fixed roof tanks should take into account a dead stock at the bottom of approx. 0.5 m and the fact that the maximum safe working level at the top is taken 0.2 m below the top curb angle.
3. The diameter of a floating roof shall at least be equal to its height, see (2.1.3).
4. The net capacity of a floating roof tank is less than the tabulated nominal capacity by approx 2.0 m of its height. This is because of a dead stock of approx. 1.2 m to keep the roof floating and the fact that the maximum working level at the top is approx. 0.8 m below the top curb angle.
   When a wind skirt is applied at the top of the shell the net capacity is less than the tabulated nominal capacity by approx. 1.2 m of its height.
5. The net capacity of a fixed roof tank with a floating cover is considerably less than the tabulated nominal capacity.
   A dead stock is approx. 1.6 m is needed to keep the cover floating. For dome roofs and cone roofs up to 12.5 m a maximum safe working level at the top is taken 0.6 m below the top curb angle and for cone roofs over 15 m diameter this max. safe working level is 0.8-2 m below the top curb angle, as the roof trusses protrude below the top of the shell.

APPENDIX 4 FITTINGS FOR STANDARD VERTICAL FIXED ROOF TANKS
(UNLESS OTHERWISE SPECIFIED ON REQUISITION SHEETS)

<table>
<tr><td colspan="2"></td><td colspan="21">Tank diameter in metres</td></tr>
<tr><td colspan="2">Description of fitting</td><td>3</td><td>4</td><td>6</td><td>8</td><td>10</td><td>12.5</td><td>15</td><td>17.5</td><td>20</td><td>22.5</td><td>25</td><td>27.5</td><td>30</td><td>33</td><td>36</td><td>39</td><td>42</td><td>45</td><td>48</td><td>54</td><td>60</td></tr>
<tr><td colspan="23">Fittings common to all fixed roof tanks</td></tr>
<tr><td colspan="2">Handrail at edge of roof</td><td colspan="21">One set, all sizes</td></tr>
<tr><td colspan="2">Handrail to centre of roof</td><td colspan="6">Not required</td><td colspan="15">One set</td></tr>
<tr><td colspan="2">Spiral staircase or ladder</td><td colspan="21">One set, all sizes</td></tr>
<tr><td colspan="2">Roof manholes</td><td colspan="4">DN 500</td><td colspan="17">DN 500</td></tr>
<tr><td colspan="2">Shell manholes</td><td colspan="4">DN 610</td><td colspan="17">Two DN 610</td></tr>
<tr><td colspan="2">Shell inlet nozzle</td><td colspan="21">As specified</td></tr>
<tr><td colspan="2">Shell outlet nozzle</td><td colspan="21">As specified</td></tr>
<tr><td colspan="2">Product drain nozzle and piping</td><td colspan="4">DN 50</td><td colspan="12">DN 100</td><td colspan="5">DN 150</td></tr>
<tr><td colspan="2">Water drain nozzle and piping</td><td colspan="21">One DN 40 all sizes, if required</td></tr>
<tr><td colspan="2">Centre drain pump</td><td colspan="21">One size, all sizes, as specified</td></tr>
<tr><td colspan="2">Roof nozzle for dip hatch device</td><td colspan="21">One set, all sizes</td></tr>
<tr><td colspan="2">Roof nozzles for vents or breather valves</td><td colspan="21">As specified</td></tr>
<tr><td colspan="2">Water spray system</td><td colspan="21">As specified</td></tr>
<tr><td rowspan="2">Foam system</td><td>Size</td><td colspan="21" rowspan="2">As specified in requisition</td></tr>
<tr><td>Number required</td></tr>
<tr><td colspan="2">Earthing boss</td><td colspan="14">2</td><td colspan="7">3</td></tr>
<tr><td colspan="2">Automatic liquid-level gauge/high level alarm</td><td colspan="21">If required/one set all sizes</td></tr>
<tr><td colspan="23">Additional fittings for Class 1 and Class II * product tanks working at pressures up to 56 mbar (ga) and a vacuum of 6.0 mbar (ga)</td></tr>
<tr><td colspan="2">Sump for tank cleaning</td><td colspan="21">As specified</td></tr>
<tr><td colspan="2">Manometer condensate trap and piping</td><td colspan="21">Boss on roof as specified</td></tr>
<tr><td colspan="2">Breather valves</td><td colspan="21">As specified</td></tr>
</table>

Slot dipping device and adapters, etc.	As specified		
Additional fittings for Class III + Unclassified * * product tanks operated at atmospheric pressure			
Swing pipe and accessories	As specified		
Sump for tank cleaning	If required		
Jacketed drain sump for bitumen tanks only	DN 150	Two DN 150	
Free vents	As specified		
Combined vent and dip hatch, DN 200 bore	Only required on large tanks		DN 200
Dip hatch, DN 150	One piece, all sizes		
Heating coils (when required)	One set, all sizes		
Suction heater (when required)	One piece, all sizes		
Clean-out door	As specified (see 6.8.3)		

* Flash point less than 55 °C

* * Flash point 55 °C and higher

APPENDIX 5 FITTINGS FOR GROUP STANDARD VERTICAL FLOATING ROOF TANKS

(UNLESS OTHERWISE SPECIFIED ON REQUISITION SHEETS)

Description of fitting	
Type of floating roof	Pontoon deck/double deck/special type
Type of seal (incl. sec. seal)	Metallic shoes/wiper type/foam seal
Spiral staircase	One set
Shell manholes	Two DN 610
Shell outlet nozzles	As specified
Shell inlet nozzles	As specified
Inlet extension pipe	One piece, all sizes
Product drain nozzle and piping	As specified
Water drain nozzle and piping	As specified
Drain sump	As specified
Sump for sludge removal	As specified
Automatic liquid-level gauge	One set, all sizes, as specified
Earthing bosses on shell	Three pieces, all sizes
Roof drain stormwater	One set, as specified
Roof earthing equipment including shunts	One set, all sizes
Seal mechanism and sealing fabric	One set, as specified
Rolling ladder	One set, with self-levelling treads
Roof manhole, DN 760	One set, all sizes
Roof compartment manhole, DN 510	One set, all sizes
Emergency drain	One set for double deck roofs only
Rim vent	As specified
Roof vent (pressure/vacuum)	As specified
Automatic bleeder valve	One set, as specified
Dip hatch	One set
Guide device	One
Roof supporting legs	One set, as provided by Manufacturer
Shell manholes for mixers	As specified
Clean-out door	As specified
Roof seal fire detection system	As specified
Foam dam/foam system	One set, all sizes/as specified
Drain plug	One set on single roof deck
High level alarm	One set, all sizes