

Tanks for the transport of dangerous goods — Metallic tanks with a working pressure not exceeding 0,5 bar — Design and construction

ICS 13.300; 23.020.20

National foreword

This British Standard is the UK implementation of EN 13094:2008, incorporating corrigenda November 2008 and November 2009. It supersedes BS EN 13094:2004 which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by CEN corrigendum November 2008 is indicated in the text by AC1 AC1, text altered by CEN corrigendum November 2009 is indicated in the text by AC2 AC2.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

**Tanks for the transport of dangerous goods - Metallic tanks with
a working pressure not exceeding 0,5 bar - Design and
construction**

Citernes destinées au transport de matières dangereuses -
Citernes métalliques ayant une pression de service
inférieure ou égale à 0,5 bar - Conception et construction

Tanks für die Beförderung gefährlicher Güter - Metalltanks
mit einem Betriebsdruck von höchstens 0,5 bar -
Auslegung und Bau

This European Standard was approved by CEN on 25 May 2008.

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Foreword

This document (EN 13094:2008) has been prepared by Technical Committee CEN/TC 296 "Tanks for transport of dangerous goods", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2009, and conflicting national standards shall be withdrawn at the latest by January 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13094:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports the objectives of the framework Directives on Transport of Dangerous Goods [1] and [2].

This European Standard has been submitted for reference into the RID and/or in the technical Annexes of the ADR.

Compared to EN 13094:2004, the following modifications have been made:

- a) Subclause 6.8 'Design stress': new form of protection was added;
- b) Revision of subclause 6.10 'Shell openings, neckrings and closures';
- c) Subclause 6.14.2 'Minimum requirements': Adoption of new forms of protection for service equipment mounted on the tank top;
- d) Updating of references, to welding standards in particular;
- e) Correction of literal mistakes.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements for the design and construction of metallic tanks with a maximum working pressure not exceeding 50 kPa gauge used for the transport of dangerous goods by road and rail for which Tank Code with letter “G” is given in chapter 3.2 of ADR [2]. It also includes requirements for a system of identification of materials used in the construction of these tanks.

This European Standard specifies requirements for openings, closures and structural equipment.

NOTE 1 This document does not specify requirements for service equipment.

This European Standard is applicable to aircraft refuellers that are used on public roads. It is also applicable to inter-modal tanks (e.g. tank containers and tank swap bodies) for the transport of dangerous goods by road and rail.

NOTE 2 This document is not applicable to fixed rail tank wagons.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 287-1, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 473, *Non destructive testing — Qualification and certification of NDT personnel — General principles*

EN 910:1996, *Destructive tests on welds in metallic materials — Bend tests*

EN 970, *Non-destructive examination of fusion welds — Visual examination*

EN 1435, *Non-destructive examination of welds — Radiographic examination of welded joints*

EN 1714, *Non-destructive examination of welds — Ultrasonic examination of welded joints*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*

EN 10204, *Metallic products — Types of inspection documents*

EN 12972:2007, *Tanks for transport of dangerous goods — Testing, inspection and marking of metallic tanks*

EN 13317, *Tanks for transport of dangerous goods — Service equipment for tanks — Manhole cover assembly*

EN 14025, *Tanks for the transport of dangerous goods — Metallic pressure tanks — Design and construction*

EN ISO 3834-1, *Quality requirements for fusion welding of metallic materials – Part 1: Criteria for the selection of the appropriate level of quality requirements (ISO 3834-1:2005)*

EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials – Part.2: Comprehensive quality requirements (ISO 3834-2:2005)*

EN ISO 5817:2007, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections (ISO 5817:2003, corrected version:2005, including Technical Corrigendum 1:2006)*

EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system (ISO 7500-1:2004)*

EN ISO 9606-2, *Qualification test of welders - Fusion welding — Part 2: Aluminium and aluminium alloys (ISO 9606-2:2004)*

EN ISO 10042:2005, *Welding – Arc-welded joints in aluminium and its alloys – Quality levels for imperfections (ISO 10042:2005)*

EN ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules (ISO 15607:2003)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1: Arc welding (ISO 15609-1:2004)*

EN ISO 15609-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2: Gas welding (ISO 15609-2:2001)*

EN ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test (ISO 15613:2004)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials – Welding procedure test – Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

EN ISO 15614-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 2: Arc welding of aluminium and its alloys (ISO 15614-2:2005)*

ISO 1496-3, *Series 1 freight containers — Specification and testing — Part 3: Tank containers for liquids, gases and pressurized dry bulk*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

3.1.1

baffle

any structure, other than a surge plate, intended to inhibit the movement of the shell contents

3.1.2

capacity

total inner volume of shell or shell compartment

NOTE When it is impossible to fill completely the shell or shell compartment because of its shape or construction, this reduced capacity should be used for the determination of the degree of filling and for the marking of the tank

3.1.3

competent authority

authority or authorities or any other body or bodies designated as such in each country and in each specific case in accordance with domestic law

NOTE Attention is drawn to ADR [2] and to the OTIF regulations (commonly referred to as RID) [3] in respect of Competent Authorities.

3.1.4

maximum working pressure

highest of the four pressures P_d , P_r , P_v and P_{ts}

3.1.5

partition

hermetically sealed dividing wall between adjacent compartments in compartmented tanks

3.1.6

section modulus

second moment of area of a structure (and, where appropriate, its associated shell) about its neutral axis divided by the maximum distance from the neutral axis to the extreme fibre of the section used in the calculation

3.1.7

shell

sheathing containing the substance carried (including the openings and their closures)

3.1.8

specific resilience

integral of the applied force and the measured deflection of a test piece up to the point at which the test bar punctures the test piece, as indicated by the point of maximum force

3.1.9.

global resilience

ability of a shell with multiple divisions or surge plates to withstand a sideways impact with a beam

3.1.10

mild steel

steel with a guaranteed minimum tensile strength of 360 N/mm^2 to 440 N/mm^2 and a guaranteed minimum elongation at fracture conforming to the requirement for steel specified in 5.2.2.3.1

3.1.11

reference steel

steel with a tensile strength of 370 N/mm^2 and an elongation after fracture of 27 %

3.1.12

surge plate

non-hermetically sealed wall in tanks or compartments of shells intended to reduce the effect of surge, mounted at right angles to the direction of travel, having an area of at least 70 % of the cross-sectional area of the shells where the surge plate is located

3.1.13

test pressure

highest effective pressure which arises in the tank during the pressure test

3.1.14

maximum permissible mass

tare of the tank and heaviest load authorised for carriage

3.2 Symbols

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

A	percentage (%) elongation after fracture
A_1	minimum percentage (%) elongation after fracture of the metal used (see 6.9.1)
B	pitch circle diameter or, if elliptical, average of major and minor diameters, in millimetres (mm)
c	distance from the start of a knuckle bend to the edge of a shell, in millimetres (mm)
NOTE 1 This is used for the attachment of a dished end to a shell.	
e	shell thickness, in millimetres (mm)
e_c	thickness of a flat closure, in millimetres (mm)
e_d	thickness of a domed closure, in millimetres (mm)
e_f	thickness of a tank end or partition, in millimetres (mm)
e_{rs}	thickness of a reinforcing section
e_r	thickness of an opening flange, in millimetres (mm)
e_{rd}	thickness of a domed closure flange, in millimetres (mm)
e_v	adopted thickness of a shell, in millimetres (mm)
$e_{v, \min}$	minimum thickness of a shell according to 6.9.1, in millimetres (mm)
e_0	minimum thickness of shell in reference steel, in millimetres (mm)
e_1	thickness of the thickest part of a shell, in millimetres (mm)
e_2	thickness of the thinner part of the metal used, in millimetres (mm)
g	acceleration due to gravity, in metres per second squared (m/s^2)

NOTE 2 The value of g is $9,81 \text{ m/s}^2$.

L	overlap of a lapped joint
L_c	length of reinforcing piece
L_r	length of reinforcing ring
L_0	initial gauge length of the test piece used in the tensile test, in millimetres (mm)
l	length of transition between plates of different thickness
l_1	length of overlap of swaged edge
l_2	length of weld at base of swaged joint
N	safety factor
P_d	highest effective pressure allowed in a shell during discharge ("maximum discharge pressure allowed"), in MegaPascals (MPa)
P_r	highest effective pressure allowed in a shell during filling ("maximum filling pressure allowed"), in MegaPascals (MPa)
P_{ts}	opening pressure of the venting system, in MegaPascals (MPa)
P_v	effective pressure to which a shell is subjected by the substance carried (including such extraneous gases as it might contain) at the design temperature, in MegaPascals (MPa)
P_x	design pressure of tank (MPa)
R	internal radius of a domed closure, in millimetres (mm)
R_d	determined tensile strength, in Newtons per square millimetre (N/mm^2)
R_e	apparent yield strength for steels having a clearly defined yield point or guaranteed 0,2 % proof strength for steels with no clearly defined yield point (1 % proof strength for austenitic steels)
R_{et}	apparent yield strength for steels having a clearly defined yield point or guaranteed 0,2 %

	proof strength for steels with no clearly defined yield point (1 % proof strength for austenitic steels) at minimum design temperature
R_m	tensile strength, in Newtons per square millimetre (N/mm ²)
R_{mt}	tensile strength at minimum design temperature, in Newtons per square millimetre (N/mm ²)
R_{m1}	minimum tensile strength of the metal used, in Newtons per square millimetre (N/mm ²)
S_B	total tensile area, in square millimetres (mm ²)
S_0	initial cross-sectional area of a test piece used in the tensile test, in square millimetres (mm ²)
w	effective depth of fillet weld (i.e. distance from the surface of the weld to the minimum penetration point of the molten metal into the base material)
Z_0	minimum section modulus in reference steel, in cubic centimetres (cm ³)
Z_1	minimum section modulus in the metal used, in cubic centimetres (cm ³)
σ_c	design stress for cover material, according to 6.8, in Newtons per square millimetre (N/mm ²)
σ_r	design stress for flange material, according to 6.8, in Newtons per square millimetre (N/mm ²)

4 Safety device

Tanks shall have a venting system and a safety device to prevent the contents from spilling out if the tank overturns.

5 Materials

5.1 General

5.1.1 The designer shall select the materials to be used in the construction of the tank using ferritic steel, austenitic steel or aluminium alloy material standards published by a national or international standards body or otherwise approved by the competent authority. The material shall in any case meet the requirements specified in 5.2.

5.1.2 Materials used in the construction of shells shall be suitable for shaping. Materials shall be deemed unsuitable if, even though they meet the material requirements of this European Standard, the degree of shaping required by a particular shell design generates cracking or other signs of distress in the shell material.

5.1.3 Materials shall be used that are known to be resistant to brittle fracture and to stress corrosion cracking.

5.1.4 When tested in accordance with the appropriate part of EN ISO 15614-1, the properties of materials used in the fabrication of welded shells shall not be less than the minimum values specified for the material selected in accordance with 5.1.1 throughout the welded area after welding without post-weld heat treatment.

5.2 Material properties

5.2.1 Impact strength

Ferritic steel materials shall be tested in accordance with EN 10045-1 using a V-shaped notch, and shall have an impact strength of not less than 34 J/cm² at - 20 °C (or at the minimum design temperature where this is lower). Impact tests shall be carried out on sheets of materials, or on their weld seams, where the sheet thickness is more than 5 mm.

5.2.2 Yield strength, tensile strength and elongation after fracture

5.2.2.1 General

5.2.2.1.1 The values of A , R_e and R_m to be used shall be the minimum values specified for the material selected in accordance with the relevant standard for the material with the exception of 5.2.2.1.2 and 5.2.2.1.3.

5.2.2.1.2 When austenitic steels are used, the value of R_e used in the calculation may exceed the minimum value in accordance with the relevant standard for the material specified for the material selected provided that:

- the higher values are attested in a certificate 3.1 issued in accordance with EN 10204;
- the value of R_e used in the calculation does not exceed 1,15 multiplied by the value of R_e as specified for the material selected in accordance with the relevant standard for the material.

5.2.2.1.3 When fine-grained steels are used, the value of R_e shall not exceed 460 N/mm² and the value of R_m shall not exceed 725 N/mm² in accordance with the specifications of the relevant standard for the material.

5.2.2.2 Yield strength and tensile strength

Steels with a ratio of R_e/R_m exceeding 0,85 shall not be used in the construction of welded tanks. The values specified in certificate 3.1 issued in accordance with EN 10204 shall be used to determine the R_e/R_m ratio.

5.2.2.3 Elongation after fracture

5.2.2.3.1 The steel shall be tested in accordance with EN 10002-1 and 5.2.2.3.3. The percentage elongation after fracture, A , shall be not less than:

- f) 16 % for fine grained steels;
- g) 20 % for other steels;
- h) 12 % for aluminium alloys.

5.2.2.3.2 Additionally, for steel, the percentage elongation after fracture, A , shall be not less than the value calculated using equation 1.

$$A = \frac{10\,000}{Rd} \quad (1)$$

5.2.2.3.3 For sheet metal, when measuring the percentage elongation after fracture in accordance with EN 10002-1, the axis of the tensile test piece shall be at right angles to the direction of rolling; where the material standard gives lower values in the direction of rolling, these values shall be used in the calculation.

5.2.2.3.4 When measuring the percentage elongation after fracture, a test piece of circular cross-section shall be used in which the initial gauge length is equal to five times the diameter. If test pieces of rectangular section are used, the gauge length shall be calculated using equation 2.

$$L_0 = 5,65\sqrt{S_0} \quad (2)$$

NOTE Elongations based on fixed lengths can be converted to proportional elongations using EN ISO 2566-1 or EN ISO 2566-2 as applicable.

5.3 Compatibility of shell materials with substances carried

5.3.1 The manufacturer shall make available a list of the dangerous goods that may be carried without damage to the tank, or its lining. The substances or group of substances approved in the certificate shall be compatible with the characteristics of the tank and its service equipment.

NOTE RID/ADR allows that the listing of approved substances may be dispensed with. In such cases, according to RID/ADR, groups of substances permitted on the basis of the tank code shown in the rationalised approach in RID/ADR 4.3.4.1.2 should be accepted for carriage taking into account any relevant special provision.

5.3.2 If contact between the substance carried and the material used for the construction of the shell is deemed likely to entail a progressive decrease in the thickness of the walls, this thickness shall be increased at manufacture by an appropriate amount.

NOTE This additional thickness, to allow for corrosion, is not taken into consideration in determining the minimum shell thickness (see 6.9.1).

5.3.3 If the shell is fitted with a non-metallic protective lining, only materials and their means of bonding to the shell that are known to remain leakproof shall be used.

5.3.4 If shells intended for the carriage of liquids having a flash-point of not more than 60 °C are fitted with non-conductive protective linings, precautions shall be taken to prevent the accumulation of electrostatic charges that could present a danger of ignition.

NOTE This requirement is also applicable to UN No. 1361 carbon and UN No. 1361 carbon black, packing group II.

6 Design

6.1 General

A shell may have a circular or a non-circular cross-section.

6.2 Design verification

The design of a tank shall be verified in accordance with one or a combination of the following methods:

- a) for shells with a circular cross-section, EN 14025 or any one of the methods specified in Annex A;
- b) for shells with non-circular cross-sections:
 - 1) dynamic testing (A.2);
 - 2) finite element stress analysis (A.3);
 - 3) reference design based on experience of the Competent Authority with existing tank designs (A.4);
 - 4) calculation method (A.5).

Documentation shall be produced that gives evidence of the design verification.

The design shall in any case conform to the minimum requirements of this European Standard.

6.3 Shell cross-section

6.3.1 For shells of non-circular cross-section:

- a) the radius of convexity of the shell wall shall not exceed 2 m at the sides and 3 m radius at the top and the bottom;
- b) there shall be a minimum radius of 200 mm linking the top/bottom and side convexities; and
- c) an equivalent diameter shall be calculated on the basis of the cross-sectional area.

6.3.2 Shell projections outside the basic cross-section of a shell shall be kept to a minimum and protection shall be provided from all directions on the shell.

6.4 Dynamic conditions

6.4.1 The dynamic conditions appropriate to the design temperature specified in 6.7, and requirements of the pressure test in EN 12972, shall be met without exceeding the stress levels specified in 6.8.

6.4.2 Shells, their attachments and their structural equipment (including partitions) shall be designed to withstand the forces and dynamic pressures resulting from the combination of the highest value of P_v or P_{ts} with, separately, each of the following, without exceeding the design stress in 6.8:

- . in the direction of travel, an acceleration of 2 g on the maximum permissible mass (in the case of self-supporting trailers the maximum permissible mass shall include the mass of axles, wheels and tyres and shall be deemed to act at the coupling point); if any account is taken of surge plates in calculations, their effect shall be proven;
- . at right angles to the direction of travel, an acceleration of 1 g acting on the maximum mass;
- . vertically upwards, an acceleration of 1 g acting on the maximum mass;
- . . vertically downwards, an acceleration of 2 g acting on the maximum mass.

6.4.3 With the following exceptions, a tank which has a maximum length of less than 2,9 m shall be designed to withstand the forces specified in 6.4.2, except that in all horizontal directions the forces shall be twice the total mass:

- . a tank permanently mounted on a vehicle chassis;
- . a demountable tank on a road vehicle which can be fitted to the chassis only in one orientation.

6.5 Pressure conditions

6.5.1 The tank shell shall be designed to withstand a maximum test pressure which shall be the greater of:

- a) the pressure created by a column of water equal to twice the depth of the tank multiplied by the relative density of the most dense substance to be carried;
- b) the pressure created by a column of water equal to twice the depth of the tank;
- c) 1,3 times the maximum working pressure.

6.5.2 Except for tanks for inter-modal tanks, compartments of compartmented tanks shall be designed to withstand a test pressure which subjects all parts of a compartment to a pressure at least equal to $1,3 \cdot (P_{ts} + \text{the liquid head of the most dense substance to be carried})$.

The test pressure shall be related to the highest point of the compartment.

6.6 Partial vacuum conditions

The shell and partitions shall be capable of withstanding a vacuum condition of 3 kPa below atmospheric pressure.

6.7 Design temperature

The minimum design temperature range shall be $-20\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$. Where the tank is likely to be subjected to more severe conditions, the design temperature range shall be extended within the range $-40\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$, as applicable. The design temperature range of tanks intended for substances to be carried at elevated temperatures shall be extended at least to the maximum working temperature.

6.8 Design stress

The maximum stress in the material of the tank and its supporting structure shall not exceed the lower of $0,75 R_e$ or $0,5 R_m$; for tank containers and tank swap bodies, the stress in the material of the supporting structure shall not exceed $0,66 R_e$.

6.9 Shell thickness

6.9.1 Minimum shell thickness

The thickness of shells made of mild steel shall be not less than the following values, unless the conditions specified in 6.9.2 are met:

- . 5 mm if the tank diameter is not more than 1,8 m;
- . 6 mm if the tank diameter is greater than 1,8 m (except in the case of shells intended for the carriage of powdery or granulated substances).

If the shell is made of another material, the equivalent minimum thickness shall be determined in accordance with equation 3.

$$e_1 = \frac{464e_0}{\sqrt[3]{(R_{m1}A_1)^2}} \quad (3)$$

If the shell thickness is increased to allow for corrosive substances, this additional thickness shall not be taken into consideration in calculating the minimum shell thickness.

The actual minimum thickness shall not be below the absolute minimum shown in Table 1.

6.9.2 Reduction of shell thickness

6.9.2.1 Where protection against damage of the shell is provided in accordance with 6.9.2.2 to 6.9.2.3, the minimum thickness may be reduced by a maximum of 2 mm of reference steel (or equivalent thickness in another material, calculated using equation 3) from that specified in 6.9.1, but shall not be below the absolute minimum shown in Table 1.

Table 1 — Absolute minimum shell thickness

Diameter ^a m	Minimum shell thickness			
	Austenitic steels mm	Other steels mm	Pure aluminium mm	Aluminium alloys mm
= 1,80	2,5 ^b	3	6	4
> 1,80	3	4	8	5

^a For non-circular cross-sections, see 6.3.1.
^b For tank-containers and tank swap bodies not protected against damage, the shell thickness shall in no case be less than 3 mm whatever the material used.

6.9.2.2 Tank vehicles and demountable tanks shall be deemed to be protected against damage when one of the following measures given in a) to i) is adopted; dimensions that refer to distances between strengthening elements shall be taken between their attachment points on the tank shell:

- a) For shells with a circular or elliptical cross-section having a maximum radius of curvature of 2 m, the shell is equipped with strengthening elements comprising partitions or surge plates, or external or internal rings, so placed that at least one of the following conditions is met:

- . the distance between two adjacent strengthening elements is less than or equal to 1,75 m;
- . the volume contained between two partitions or surge plates is less than or equal to 7 500 l.

A ring, and associated shell shall have a section modulus of at least 10 cm³ in reference steel, or an equivalent section modulus in another metal (see 6.14.2.5), when calculated around the neutral axis parallel to the shell.

External strengthening elements shall not have projecting edges with a radius of less than 2,5 mm.

- b) For shells with double walls having an intermediate layer of rigid solid material (e.g. foam, at least 50 mm thick), the outer wall has a thickness of at least 0,5 mm of mild steel, 0,8 mm of aluminium or 2 mm of fibre reinforced plastic material. For other insulating materials (e.g. mineral-wool, at least 100 mm thick), the outer wall has a thickness of at least 0,8 mm of austenitic steel, the outer wall of the ends may be of a fibre reinforced plastic material with a thickness of at least 3 mm.

Other combinations of materials used to provide protection against damage shall have specific resilience, as determined in accordance with Annex B, equivalent to that of the minimum thickness required by 6.9.1, and the thickness of the inner wall of the combination shall be not less than the minimum value specified in 6.9.2.1.

- c) For shells of forms other than in a), the shell is provided all around the mid-point of its vertical height and over at least 30 % of its height with additional protection designed in such a way as to offer specific resilience, as determined in accordance with Annex B, at least equal to that of a shell constructed in reference steel of a thickness of 5 mm for a shell diameter not exceeding 1,80 m or 6 mm for a shell diameter exceeding 1,80 m.

The additional protection shall be applied in a durable manner to the outside of the shell.

This requirement shall be deemed to have been met without further proof of the specific resilience when

- . the additional protection involves the welding of a plate of the same material as the shell to the area to be strengthened, such that the shell thickness is not less than the minimum specified in 6.9.1; and
- . flanged ends to the full thickness are used with the additional side protection extending to cover at least one third of the flange length.

- d) For shells made with single ends having the full thickness specified in 6.9.1, the shell has partitions and surge plates meeting both of the following requirements:
- . the capacity contained between two partitions is less than or equal to 7 500 l;
 - . the volume between partition and surge plate is less than or equal to 4 000 l.
- e) For shells made with double ends, the shell has partitions and surge plates meeting both of the following requirements:
- . the capacity contained between two partitions is less than or equal to 7 500 l;
 - . the volume between partition and surge plate is less than or equal to 4 000 l.

The inner end shall have a thickness at least equal to the minimum specified in 6.9.2.1 and the outer end a thickness of at least 2 mm in reference steel or an equivalent thickness in another metal, calculated using equation 3.

- f) For shells made with double ends with a separation exceeding 100 mm, the ends of which conform to the requirements specified in e), the shell has partitions arranged such that the capacity contained between partitions is less than or equal to 7 500 l.
- g) For shells of forms other than in a), the following conditions are all met:
- . the volume contained between adjacent partitions or surge plates does not exceed 7 500 l;
 - . the volume of any compartment does not exceed 15 000 l except in the case of tanks dedicated to the carriage of liquids at or above 100 °C and below their flashpoint;
 - . the distance between adjacent partitions and surge plates does not exceed 1,4 m;
 - . the corner radii connecting the top, side and bottom radii are not less than 300 mm;
 - . the thicknesses of ends conform to d) or e) as appropriate.
- h) For demountable tanks, protection is provided on all sides by the drop sides or the cab of the carrying vehicle. The drop sides shall offer protection to at least half the height of the shell.
- i) For shells of forms other than in a), when applying requirements of global resilience, the following conditions are all met:
- . the volume contained between adjacent partitions or surge plates does not exceed 7 500 l;
 - . the volume of any compartment does not exceed 15 000 l except in the case of tanks dedicated to the carriage of liquids at or above 100 °C and below their flashpoint;
 - . the distance between adjacent partitions and surge plates does not exceed 1,75 m;
 - . the average distance between adjacent partitions or surge plates does not exceed 1,4 m;
 - . the corner radii connecting the side, top and bottom radii are not less than 250 mm;
 - . the thickness of the ends are conform to d) or e) as appropriate;
 - . for shells made with double ends with a separation exceeding 100 mm, the ends shall conform to the requirements specified in e);
 - . the weakest 4 m-shell segment has a global resilience of at least 100 kNm.

The following values for global resiliencies shall be used:

- 1) for partitions or surge plates with a maximum thickness specified in 6.9.1: 40 kNm;
- 2) for partitions or surge plates with a minimum thickness specified in 6.9.2.1: 20 kNm;
- 3) for ends: 20 kNm.

Higher values of global resiliencies and global resiliencies for other types of reinforcement members shall only be used if confirmed by tests carried out in accordance with B.5 or an equivalent approved by the Competent Authority.

6.9.2.3 Shells of fixed tanks and demountable tanks that either are of not more than 5 000 l capacity or are divided into tank compartments of not more than 5 000 l capacity shall be deemed to be protected against damage if their thickness in mild steel or their equivalent thickness calculated according to formula 3 for other materials is not less than the values given in Table 2.

Table 2 — Minimum shell thickness for small and compartmented tanks

Capacity of shell or shell compartment	Maximum radius of convexity top and bottom	Maximum radius of convexity of sides	Minimum thickness of reference steel	Other steels	Austenitic stainless steels	Aluminium alloys	Pure aluminium
m ³	m	m	mm	mm	mm	mm	mm
= 3,5	3	2	3	3	2,5	4	6
> 3,5 but ≤ 5	3	2	4	4	3	5	8
≥ 5	2	2	3	3	2,5	4	6

Tank containers and swap bodies shall be deemed to be protected against damage when one of the following measures is adopted:

- a) the shell is made with double walls in accordance with 6.9.2.2 b); or
- b) there is a structure, conforming to the requirements of ISO 1496-3, in which the shell is supported by a complete skeleton including longitudinal and transverse structural members.

6.10 Shell openings, neckrings and closures

6.10.1 Inspection openings and manholes

Each tank and compartment with a capacity of 3 000 l or greater shall be provided with a manhole to allow inspection of the interior. Tanks and compartments with a capacity of less than 3 000 l shall be provided with either an inspection opening or a manhole.

The diameters of openings shall be:

- not less than 100 mm and not more than 300 mm for inspection openings;
- not less than 500 mm for circular manholes.

For non-circular manholes, no dimension shall be less than 500 mm.

NOTE It is advisable to allow access with full rescue facilities including self-contained breathing apparatus.

The minimum dimensions of manhole and inspection openings in lined vessels shall be maintained after the lining is applied.

6.10.2 Neckrings and closures

The neckring and flange of an opening shall conform to Annex C.

Cover plates, fixings and their sealing faces shall be designed to withstand an internal pressure of not less than 265 kPa.

The materials used in the formation of openings, sealing faces and cover plates shall be in accordance with Clause 5.

6.10.3 Cover plates

Closures that cover openings with an interior diameter of 200 mm or more shall be made of metallic materials in accordance with Clause 5.

6.10.4 Mountings for service equipment

The mountings for service equipment shall be arranged so as to permit protection against the risk of the equipment being wrenched off or damaged, and shall meet any strength requirements specified by the equipment manufacturer.

6.11 Shell partitions, surge plates and baffles

6.11.1 Surge plates and partitions shall be either:

- a) dished, with a depth of dish of not less than 100 mm; or
- b) corrugated, profiled or otherwise reinforced.

When the design verification techniques in A.3 or A.5 are used, the depth of dish (resulting from the crown radius) shall be verified.

6.11.2 Partitions and surge plates, including any backing plates, shall be continuously welded to the shell except as required by 6.11.4.

6.11.3 The thickness of partitions and surge plates shall not be less than the minimum thickness of the shell; for partitions, the material properties shall be at least the same as those of the shell itself, when having the minimum thickness.

6.11.4 Surge plates, baffles and strengthening elements extending more than 70 mm from the inner surface of the shell shall have openings at the top, bottom and sides to assist in emptying the tank in the partly or fully overturned position and to prevent vapour locks rendering level detection systems ineffective during filling. Openings at the top shall have a total cross-sectional area of at least 2 000 mm² entirely above a horizontal line 100 mm below the top of the shell cross-section. Openings in the bottom shall, together with any sumps, allow complete drainage to the discharge point.

6.11.5 Compartments adjacent to ends shall not be fitted with longitudinal partitions. Where longitudinal baffles or surge plates are fitted in compartments adjacent to ends, there shall be a clearance of at least 200 mm between them and the end of the tank at any point.

6.12 Attachments to the shell

6.12.1 Reinforcements for attachments to the shell shall be designed such that the stress specified in 6.8 is not exceeded.

6.12.2 The means by which attachments are fixed to the shell shall be designed to take into account the purpose of the attachment and the risk of damage to the shell when the attachment is subjected to additional forces.

6.12.3 Drainage facilities shall be provided where otherwise sealed spaces are created between the product containing skin of the shell and internal or external attachments, and reinforcements. The drainage facilities shall not be sealed.

6.12.4 Pipes passing through the shell shall be placed and designed in such a way as to minimize the risk of damage to the shell when external forces are applied to the pipe or shell. Pipes with an internal diameter exceeding 55 mm, with a length outside the shell of more than 50 mm at any place, shall be designed such that, in the event of accidental damage to the pipe outside the tank, the external section of the pipe breaks away without damaging the shell. The wall thickness of pipes shall be not less than the thickness shown in Table 3, or the thickness of the shell, whichever is the lower. Open pipes passing through the shell that are not used for drainage shall extend outside the shell for a minimum length of 20 mm.

Table 3 — Minimum thickness of pipes passing through the shell

Dimensions in millimetres			
Internal diameter	Austenitic steel	Mild steel	Aluminium alloy
≤ 55	2,5	3,0	4,0
> 55	3,0	4,0	5,0

6.13 Shell supporting structure

6.13.1 Shell supporting structures shall be designed such that the stresses specified in 6.8 are not exceeded when they are subjected to the static and dynamic loading forces specified in 6.4.1, 6.4.2 and 6.4.3.

6.13.2 Shell supporting structures to be welded at the shell shall be provided with a backing plate or locating reinforcement as a means of conforming to 6.13.1. Materials used for backing plates or other reinforcements, welded directly to the shell, shall be known to be compatible with the material of the shell, and capable of being welded without producing defects.

6.14 Protection of service equipment mounted on the tank top

6.14.1 General requirements

6.14.1.1 Protection against damage caused by overturning shall be provided on the tank shell so that it contains entirely service equipment mounted on the top of the shell that connects with the inside of the shell.

6.14.1.2 The protecting device(s) and the mounting position(s) for the service equipment shall be designed in such a way that the service equipment mounted on the upper part of the shell is at least 25 mm within the contour of the protecting device.

6.14.1.3 Where the area surrounded by the protecting device is not self-draining, a drainage system shall be provided.

6.14.1.4 The complete tank top protection shall be designed to withstand, without permanent deformation, a static load, applied vertically, equal to twice the laden mass of the tank vehicle. This requirement shall be deemed to be met when the protecting device conforms to the requirements specified in 6.14.2.

6.14.2 Minimum requirements

6.14.2.1 General

Specific forms of protection shall meet the requirements specified in the following subclauses:

- a) 6.14.2.2 for longitudinal and transverse members;
- b) 6.14.2.3 for shell contours;
- c) 6.14.2.4 for spill-trays;
- d) 6.14.2.5 for roll-over bars;
- e) 6.14.2.6 for transverse box sections

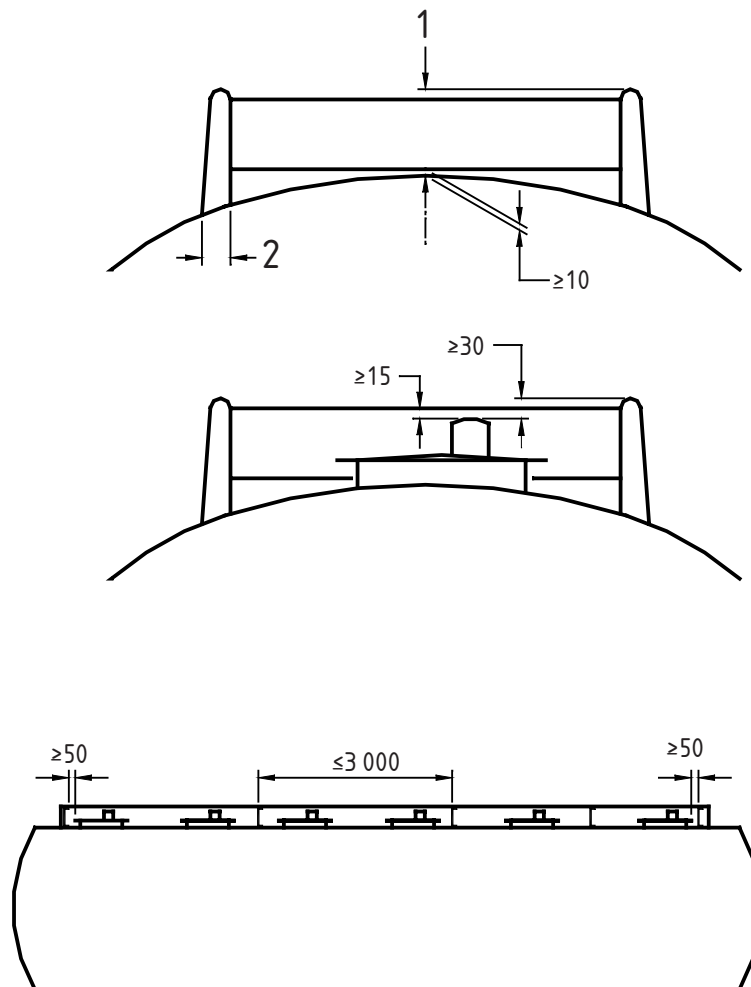
6.14.2.2 Longitudinal and transverse members

NOTE 1 A typical arrangement of service equipment protected by longitudinal and transverse members is shown in Figure 1.

Where longitudinal and transverse members are used to protect the service equipment:

- a) they shall be designed to form an enclosed box-section when mounted on the tank top;
- b) the width of longitudinal members, measured at the level of the tank top, shall be not less than one third of the height;
- c) the height of the longitudinal members shall be not less than the highest item of service equipment plus 30 mm;
- d) transverse members shall support both longitudinal members and the spacing between them shall not exceed 3 000 mm;
- e) transverse members shall extend at least 50 mm in front of the first item of service equipment and at least 50 mm behind the last item of service equipment;
- f) the height of the transverse members shall not be less than the highest item of service equipment plus 15 mm;
- g) the vertical distance between transverse members and the shell at the tank centre line shall be not less than 10 mm;
- h) the cross-section of the transverse members shall have a minimum section modulus about the horizontal axis of at least 10 cm^3 in reference steel or equivalent in another metal. The section modulus shall be maintained where cutaways are provided for separate vapour collection or other pipes;
- i) transverse members shall have at least one drain opening at the lowest point;
- j) the wall thickness of the longitudinal members and the transverse members shall be not less than:
 - 1) 2,5 mm for mild steel;
 - 2) 2 mm for austenitic steel;
 - 3) 4 mm for aluminium alloy.

NOTE 2 Longitudinal members can be used for vapour collection.



Key

- 1 Height of longitudinal protection member above top of shell (measured at top centre line of shell)
- 2 Width of longitudinal protection member (measured at its base) – not less than one third of the height.

Figure 1 — Typical arrangement of service equipment protected by longitudinal and transverse members

6.14.2.3 Shell contours

NOTE A typical arrangement of service equipment protected by the contour of a shell is shown in Figure 2.

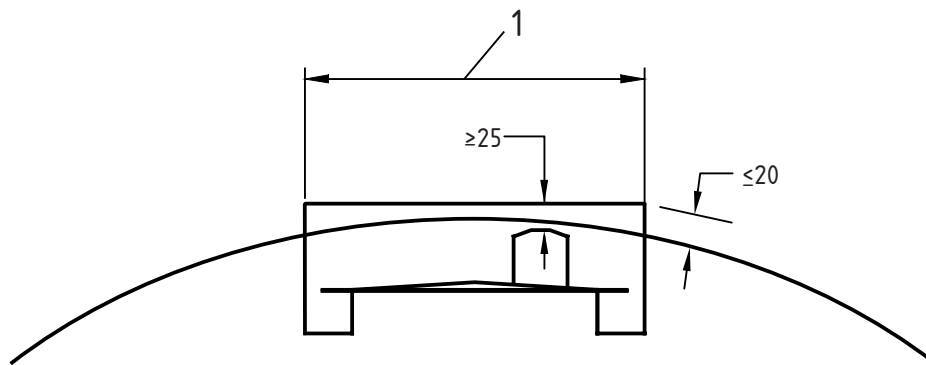
Where items of service equipment are positioned entirely within the contour of the shell for protection:

- a) they shall be mounted in a protective ring recessed into the shell in such a way that they are at least 25 mm within the contour of the upper edge of this ring;
- b) the ring shall not extend outside the contour of the shell by more than 20 mm;
- c) the exterior diameter of the protecting ring shall be not more than 700 mm;

d) the wall thickness of the ring shall be not less than:

- 1) 6 mm for mild steel;
- 2) 4 mm for austenitic steel;
- 3) 8 mm for aluminium alloy.

Dimensions in millimetres



Key

1 = 700 outside

Figure 2 — Typical arrangement of service equipment protected by the contour of a shell

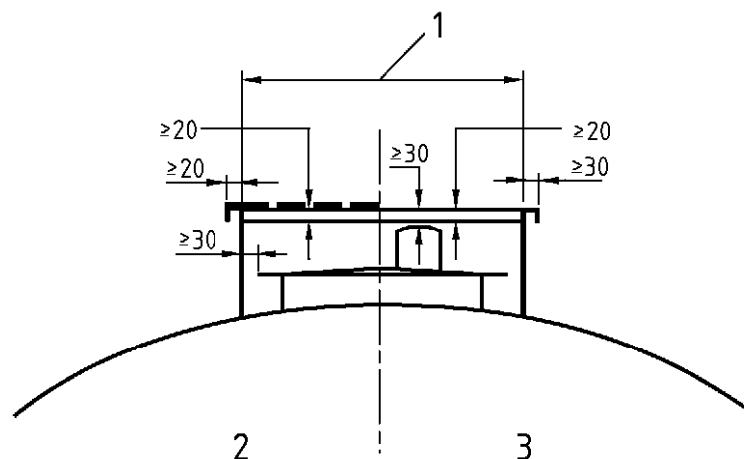
6.14.2.4 Spill-trays

NOTE 1 A typical arrangement of service equipment protected by spill-trays is shown in Figure 3.

Where spill-trays are used to protect the service equipment:

- a) they shall be the height of the highest item of service equipment plus 30 mm;
- b) they shall enclose all components of the service equipment completely with a minimum lateral clearance of 30 mm between the spill-tray and the equipment being protected;
- c) where spill-trays without covers are used, the upper edge of the spill-tray shall be angled twice, not less than 30 mm (horizontally) and 20 mm (vertically down);
- d) where spill-trays with covers are used, the upper edge of the spill-tray shall be angled twice, not less than 20 mm (horizontally) and 20 mm (vertically down);
- e) the exterior diameter shall not exceed 900 mm or, if rectangular, the width shall not exceed 900 mm and the length shall not exceed 1 500 mm;
- f) the wall thickness shall be not less than:
 - 1) for spill trays:
 - 4 mm for mild steel;
 - 2,5 mm for austenitic steel;
 - 6 mm for aluminium alloy;
 - 2) for protective covers:
 - 2 mm for mild steel;
 - 1,5 mm for austenitic steel;
 - 3 mm for aluminium alloy.

Dimensions in millimetres



Key

- 1 = 900 width, diameter, = 1 500 length (if rectangular)
 2 Spill tray with cover
 3 Spill tray without cover

Figure 3 — Typical arrangement of service equipment protected by spill-trays

6.14.2.5 Roll-over bars

NOTE 2 A typical arrangement of service equipment protected by roll-over bars is shown in Figure 4.

Roll-over bars shall be positioned on strengthening elements of the shell, such as partitions or surge plates.

The values of the section modulus are applicable to reference steel (Z_0); if another material is used for the roll-over bars, the equivalent section modulus in that material (Z_1) shall be determined in accordance with equation 4. If mild steel is used no calculation is required.

$$Z_1 = \frac{10\,000}{R_{m1} A_1} \cdot Z_0 \quad (4)$$

Where service equipment is protected by roll-over bars:

- a) the roll-over bars shall be at right angles to the direction of travel;
- b) the roll-over bars shall be as low as possible;
- c) the service equipment shall be not less than 50 mm within the contour of the roll-over bar;
- d) the roll-over bars shall be placed in front of the first and behind the last item of service equipment;
- e) the distance between the individual roll-over bars shall be not more than 3000 mm;
- f) the section modulus of each roll-over bar shall be not less than 5 cm³ plus an additional 1 cm³ for each 1000 l of shell capacity with a maximum of 30 cm³;
- g) the roll-over bars and bracings shall be connected to the shell on locally reinforced places to reduce the risks of damage to the shell;
- h) the roll-over bars shall be braced for stability on the longitudinal axis of the shell;
- i) the angle to the shell of the bracings shall be not more than 45°;
- j) the bracings shall be attached as high as possible to the roll-over bar;
- k) the section modulus of the bracings together shall be not less than the value of the roll-over bar;
- l) where strengthening plates are used as bracings, their resistance to buckling shall not be less than that of tubing complying with h), i), j), and k).

Dimensions in millimetres

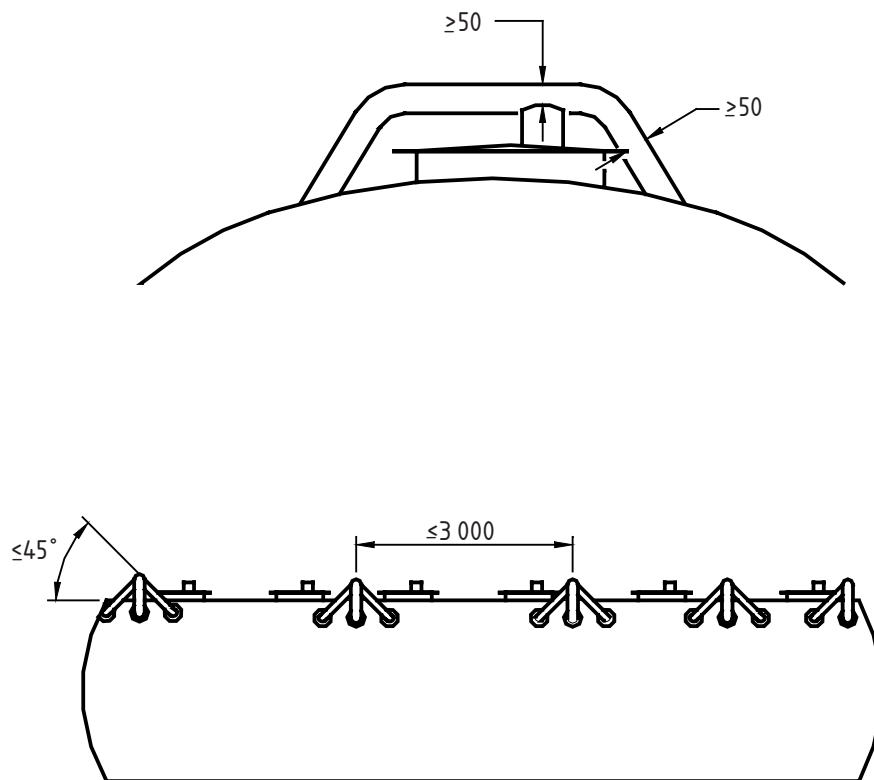


Figure 4 — Typical arrangement of service equipment protected by roll-over bars

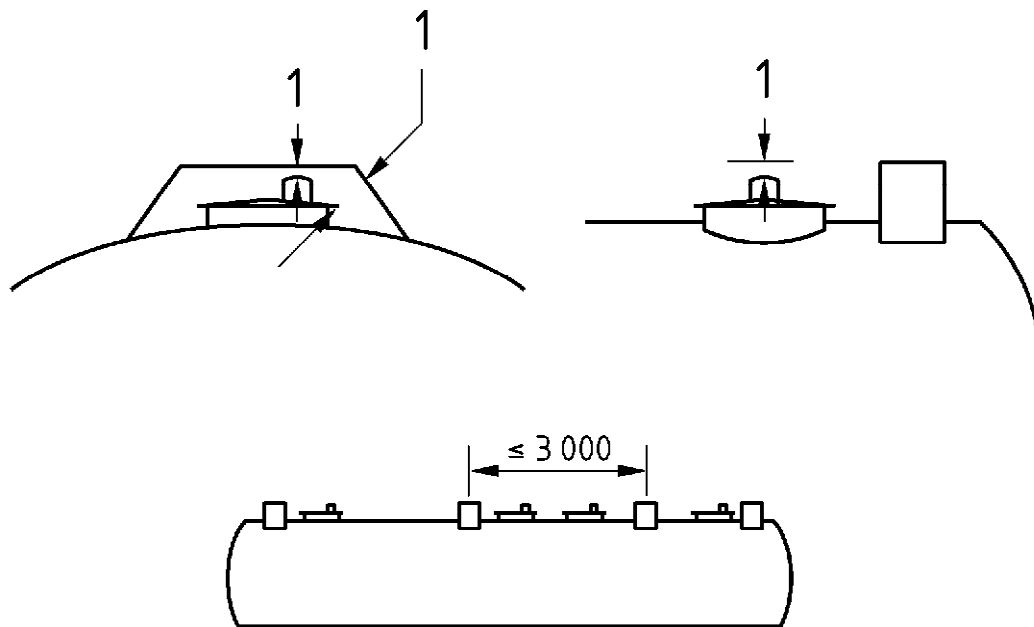
6.14.2.6 Transverse box sections

NOTE A typical arrangement of service equipment protected by transverse box sections is shown in Figure 5.

Where service equipment is protected by transverse box sections:

- a) they shall be constructed from the same material as the tank shell as sheet metal fabrications, continuously welded to the shell and forming closed sections with it;
- b) the height of the transverse box sections shall be as low as possible but in any case:
 - 1) for tanks for granular substances, not less than the highest item of service equipment plus 25 mm.
 - 2) for tanks for all other substances, not less than the highest item of service equipment plus 50 mm.
- c) they shall be placed in front of the first and behind the last item of service equipment;
- d) the distance between transverse box sections shall be not more than 3 000 mm;
- e) the section modulus of each transverse box section shall be not less than 5 cm^3 plus an additional 1 cm^3 for each 1000 l of shell capacity with a maximum of 30 cm^3
- f) where material other than mild steel is used for the transverse box section, an equivalent section modulus shall be calculated using the formula given in 6.14.2.5.
- g) if the width of the transverse box section is greater than its height, measured at the highest point over the shell, no additional bracing is necessary; otherwise the provisions of 6.14.2.5 shall apply.

Dimensions in millimetres



Key

- 1 = 25 for granular substances
= 50 for all other substances

Figure 5 — Typical arrangement of service equipment protected by transverse box sections

7 Manufacture

7.1 General

7.1.1 Manufacturing processes shall be such that the degree of shaping required by a particular shell design does not generate cracking or other signs of distress in the shell material.

7.1.2 The manufacturer of the shell shall maintain a system of identification for the material used in the fabrication in order that all material in the shell can be traced to its origin. The system shall:

- a) incorporate appropriate procedures that aim at verifying the identity of materials of the shell and its supporting structure received from suppliers, and that shall be based on the provision of material certificates 3.1 in accordance with EN 10204, and/or acceptance tests;
- b) specify that before cutting and forming parts of the shell, the original identification mark of the material is transferred to any part that would be without the marking after the process has been completed.

7.2 Cutting and edge preparation

7.2.1 Material shall be cut to size and shape by thermal cutting, machining, cold shearing or other suitable process. Surfaces that have been thermally cut shall be dressed back by machining or grinding to remove severe notches, slag and scale. Plates over 10 mm thick that have been cold sheared shall be dressed back prior to welding. The cut edges of ferritic alloy steels, which have been cut by a thermal process, shall be dressed back by grinding or machining for a distance of at least 1,5 mm unless the fabricator can demonstrate that the material has not been adversely affected by the cutting process.

7.2.2 Edges which are to be welded shall be inspected after cutting and preparation, and the welding shall be carried out only if none of the following defects are present:

- . tearing of the material (laminations);
- . patches of mill scale;
- . stress cracks due to oxygen cutting;
- . copper or carbon deposits;
- . split ends open to the surface;
- . traces of paint, except when the paint is not expected to adversely affect the welding quality;
- . traces of grease or other surface contamination that might adversely affect the welding quality;
- . slag inclusions.

7.3 Forming

7.3.1 General

Materials shall be formed to the required shape by any suitable process providing that the extent of the bends and the radii do not exceed that specified in the material standard. After forming, the thickness shall not be less than the minimum specified in 6.9.1. Plates shall be formed to the correct contour up to their edges unless they are to be dressed after forming.

7.3.1.1 If plates are to be butt welded together prior to forming, the joint shall be non-destructively tested as specified in 7.4.4, after forming when the radius of the formed section is less than 20 times the thickness of the material for steels and 40 times the thickness of the material for aluminium.

NOTE When sheets of different thicknesses are butt welded together prior to forming, this value should be taken as the thickness of the thicker sheet.

7.3.1.2 When applicable, the weld itself shall be ground back prior to forming to avoid severe stresses in the weld.

7.3.2 Hot forming

7.3.2.1 Where a hot forming process is used, the material strength after forming shall be not less than the minimum specified in the material specification for those properties given in 5.2.

7.3.2.2 Heavy scale remaining after any hot forming process shall be removed by a descaling process that has been proven not to reduce the mechanical and corrosion-resisting properties below those required by the original design.

7.3.2.3 Austenitic steel plates that are to be heated or hot worked shall be heated uniformly in a neutral or oxidizing atmosphere, without flame impingement, to a temperature not exceeding the hot working temperature recommended by the manufacturer of the material. Forming shall not be carried out if the temperature of the material has fallen below 900 °C; slow cooling between 750 °C and 600 °C shall be avoided.

7.4 Welding

7.4.1 Qualification

7.4.1.1 A welding quality assurance system shall be operated and maintained that is in accordance with EN ISO 3834-1 and EN ISO 3834-2.

7.4.1.2 Welding procedures shall be approved in accordance with the relevant parts of EN ISO 15607, EN ISO 15609-1, EN ISO 15609-2 or EN ISO 15614, as appropriate.

The manufacture of welded shells shall be carried out by persons who are qualified to EN 287-1 or EN ISO 9606-2 as applicable.

7.4.2 Welded joints

7.4.2.1 Weld details shall be selected to take into account:

- . the method of manufacture;
- . the service conditions;
- . the ability to carry out necessary non-destructive testing.

7.4.2.2 Examples of suitable weld details are given in Annex D, but other weld details may be used provided that they are found to be suitable when tested in accordance with EN ISO 15614-1, EN ISO 15614-2 or EN ISO 15613 as applicable.

7.4.2.3 Where any part of a shell is made in two or more circumferential sections, either:

- . the longitudinal welds of adjacent sections shall be separated by not less than 50 mm; or