



BS 5045 : Part 2 : 1978

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Specification for

Transportable gas containers

Part 2. Steel containers up to 130 litres
water capacity with welded seams

Spécification des récipients à gaz transportables

Partie 2. Récipients en acier de capacité jusqu'à 130 litres d'eau avec
joints soudés

Spezifikation für transportfähige Gasbehälter

Teil 2. Stahlbehälter mit einer Wasserkapazität bis 130 Liter mit
geschweissten Nähten

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BS 5045 : Part 2 : 1978

Contents

	Page		Page
Foreword	1	Section six. Marking of containers	
Cooperating organizations	Back cover	31. Information to be marked	17
Specification		32. Method of marking	17
Section one. General		Appendices	
1. Scope	2	A. Volumetric expansion testing of welded containers	18
2. References	2	B. Examples of design procedure	23
3. Manufacture and testing of containers	2	C. Specimen certificate of compliance for welded steel gas containers	24
4. Classification of gases	2		
5. Information to be supplied by the purchaser and the manufacturer	2	Tables	
6. Certificate of compliance	3	1. Permissible deviations on product analysis	3
Section two. Materials		2. Permissible materials	3
7. General	3	3. Reference temperatures for developed pressure for conveyance in the United Kingdom in uninsulated containers	4
8. Permissible materials	4	4. Classification of gases	5
9. Material for attachments subject to pressure	4	5. Summary of classification of containers and of provisions according to class	6
Section three. Design		6. Relationship between test pressure, pressure developed at the reference temperature and gas classification	7
10. Service conditions for design	4	7. Stress reduction factors for the cylindrical part of the shell	7
11. Classification of containers	4	8. Maximum permissible equivalent stress at test pressure for the cylindrical part of the shell	9
12. Design of container shell	4		
13. Openings and branch connections	9	Figures	
14. Fittings	11	1a. Shape factor K	8
Section four. Manufacture and workmanship		1b. Shape factor K (enlargement of figure 1a)	9
15. Approval of design and construction details	11	2. Domed ends	10
16. Tolerances	11	3. Location of test specimens in a container	15
17. Welds	12	4. Reduced section tensile test specimen	16
18. Heat treatment	12	5. Nick-break test piece	16
Section five. Inspection and tests		6. Water jacket volumetric expansion test (levelling burette)	19
19. General	12	7. Water jacket volumetric expansion test (fixed burette)	19
20. Inspection of components	12	8. Non-water jacket volumetric expansion test	20
21. Test requirements	12		
22. Mechanical tests	13		
23. Hydraulic volumetric expansion test	13		
24. Hydraulic bursting test	14		
25. Pressure test	14		
26. Tightness test	14		
27. Radiographic examination of welds	14		
28. Repair of welds	14		
29. Checking of water capacity	17		
30. Results of mechanical and pressure tests	17		

Foreword

This British Standard, prepared under the direction of the Pressure Vessel Standards Committee, is one of a series based on the recommendations in the report (published 1969) of the Home Office Gas Cylinders and Containers Committee for materials, design, construction, testing, filling and maintenance of containers intended for the conveyance by road of permanent, liquefiable and dissolved gases, under pressure.

This particular standard deals with the materials, design, construction and testing of new containers, and is being prepared in several Parts to cover the various forms of manufacture. Those Parts published or in preparation are as follows:

- Part 1 Seamless steel containers
- Part 2 Steel containers up to 130 litres water capacity, with welded seams
- Part 3 Seamless aluminium alloy containers (In course of preparation)
- Part 4 Steel containers with circumferential and longitudinal welded seams and with a water capacity in excess of 450 litres (In course of preparation)

This Part was originally published in 1974, covering steel containers having automatically welded circumferential seams only. This revision has been made to incorporate containers with both longitudinal and circumferential seams and to make it applicable to containers for dissolved acetylene.

Containers manufactured to this standard should be manufactured by a container manufacturer on the Health and Safety Executive list of recognized manufacturers of steel containers. The steel from which the containers are made should have been manufactured by a steel manufacturer on the Health and Safety Executive list of recognized manufacturers of steel for containers. The method of manufacture and the testing of the containers should be carried out to the satisfaction of an Independent Inspecting Authority.

Other related standards are BS 5355 and BS 5430.

Pending new regulations, the Health and Safety Executive has published a letter recommending the use of this British Standard for the construction of containers used for the conveyance of gases not subject to statutory control and indicating 'no objection' to the conveyance by road in containers constructed to this standard of those compressed gases subject to the present Gas Cylinders (Conveyance) Regulations. The text of the letter is as follows:

Health and Safety Executive
Baynards House
1-13 Chepstow Place
Westbourne Grove
London W2

Our reference: X1 9260/6/3

Date: 3 January 1978

Gentlemen,

The British Standards Institution is about to issue a revised specification, BS 5045 : Part 2 : 1978, for the construction of steel containers with welded seams for the conveyance of compressed gases.

It is recommended that, where steel containers with welded seams are used for the conveyance of those gases which are not subject to statutory control, they should be constructed in accordance with this specification.

New regulations to replace the present Gas Cylinder (Conveyance) Regulations are under consideration. In the meantime, no objection will be taken to the conveyance by road of the compressed gases to which those Regulations apply (air, argon, carbon monoxide, coal gas, hydrogen, methane, neon, nitrogen and oxygen) in steel containers with welded seams which are constructed in accordance with this specification, provided that they shall have been manufactured by a manufacturer on the Health and Safety Executive list of recognized manufacturers of steel containers and that the steel from which the containers have been made shall have been manufactured by a manufacturer on the recognized list of manufacturers of that Executive. This requirement shall also apply to containers used for the carriage of dissolved acetylene.

I am, Gentlemen,
Your obedient servant,
M. G. Sewell
HM Deputy Chief Inspector of Explosives

British Standard Specification for

Transportable gas containers

Part 2. Steel containers up to 130 litres water capacity
with welded seams

Section one. General

1. Scope

This Part of BS 5045 specifies requirements for the materials, design, construction and testing of containers for the conveyance of gases under pressure; such containers are suitable also for storing gas under pressure. It applies to steel containers of water capacity up to 130 litres having longitudinal and/or circumferential main seams, made by a fully or semi automatic welding process.

It includes appendices giving examples of design calculations, a description of the methods for pressure testing of containers and a model form of test certificate.

2. References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

3. Manufacture and testing of containers

The manufacture and testing of containers complying with the requirements of this British Standard shall be carried out to the satisfaction of an Inspecting Authority which is independent of the manufacturer and which is on the Health and Safety Executive list of recognized inspecting authorities, hereinafter referred to as the Independent Inspecting Authority.

4. Classification of gases

For the purposes of the design and filling of the container, gases are classified as follows.

Permanent gases. Those gases which have a critical temperature below -10°C .

Liquefiable gases. Those gases which are liquefiable by pressure at -10°C but which boil below 17.5°C when at not more than 1013 mbar*.

High pressure liquefiable gases are those having a critical temperature between -10°C and 70°C .

Low pressure liquefiable gases are those having a critical temperature above 70°C .

Those toxic substances which are liquids at 1013 mbar* at 0°C but which boil at or below 30°C at that pressure, shall be treated as low pressure liquefiable gases.

Dissolved gas (acetylene). A gas which is dissolved under pressure in a solvent contained in a porous substance at ambient temperature and which is released from the solvent without the application of heat.

Some gases which are currently conveyed in commercial

quantities are classified as in table 4.

5. Information to be supplied by the purchaser and the manufacturer

5.1 Information to be supplied by the purchaser. The purchaser shall inform the manufacturer of the following as appropriate:

- (a) name or classification of gas(es);
- (b) class of construction (e.g. BS 5045 : Part 2, Class 1A);
- (c) volumetric capacity (minimum for liquefiable gases);
- (d) for permanent gases, the filling pressure at 15°C ;
- (e) for liquefiable gases, the mass of gas or filling ratio at the prescribed reference temperature or the minimum required developed pressure in service;
- (f) material of construction;
- (g) preferred dimensions;
- (h) type of base;
- (i) internal and/or external neck screwing dimensions;
- (j) fittings required;
- (k) external/internal finish required;
- (l) any special or adverse conditions under which the container will be required to operate, and any corrosion allowance required;
- (m) whether any addition is required to the requirements of this standard;
- (n) the name of the Independent Inspecting Authority.

5.2 Information to be supplied by the manufacturer. The manufacturer shall supply the purchaser and the Independent Inspecting Authority with the following information.

- (a) Fully dimensioned sectional drawing of the container including:
 - name or classification of gas(es);
 - volumetric capacity (minimum for liquefiable gases);
 - filling pressure at 15°C for permanent gas(es) or mass of liquefiable gas(es);
 - material of construction;
 - test pressure;
 - minimum and maximum masses of container;
 - statement that the container will be constructed to the requirements of this standard;
 - design approval reference (see clause 15);
 - amount of corrosion allowance (if any);
 - large scale dimensional details of the weld preparation for all seams and details of the joints.
- (b) Fittings to be supplied.

*1 bar = 10^5 N/m^2 = 100 kPa.

Table 1. Permissible deviations on product analysis

Element	When the maximum of the specified range is	Permissible deviation on product analysis (see note)
Carbon	up to and including 0.25 % over 0.25 %	0.02 % 0.03 %
Silicon	up to and including 0.60 %	0.05 %
Manganese	up to and including 1.0 % over 1.0 %	0.08 % 0.10 %
Phosphorus	up to and including 0.050 %	0.010 %
Sulphur	up to and including 0.050 %	0.010 %
Niobium	up to and including 0.10 %	0.02 %

NOTE. Maximum and minimum values do not apply simultaneously for individual elements: see 7.5.

(c) Marking arrangement drawing.

(d) Certificate of compliance for materials and container.

No modification shall be made to the design, after approval by the Independent Inspecting Authority, except with prior agreement between the purchaser, manufacturer and Independent Inspecting Authority. In the case of dissolved acetylene such agreement shall be obtained from HM Inspector of Explosives.

6. Certificate of compliance

The Independent Inspecting Authority shall certify that the manufacture of the container was carried out in accordance with the requirements of this standard.

NOTE. A suitable form of certificate is shown in appendix C.

Section two. Materials

7. General

7.1 The materials used for the pressure parts of the container shall be in accordance with the appropriate requirements of clauses 8 and 9.

7.2 The materials shall be supplied in such a manner that the specified mechanical properties are obtained in the finished container after heat treatment.

7.3 Each bundle or coil shall be marked with the number of this British Standard together with the type letter (see table 2), and with numbers or other identification marks by which it can be traced to the ladle of steel from which it was made. If the plate or sheet is not supplied directly by the steelmaker to the container manufacturer, then the material shall also be marked to identify the steelmaker.

7.4 Steel suppliers shall provide an appropriate manufacturer's certificate with each batch of steel giving details of ladle analysis and mechanical properties.

7.5 The ladle analysis of materials shall be within the composition limits given for the steels listed in table 2. In the event of one melt being divided between more than one ladle, samples shall be analysed from each ladle and a separate analysis provided for each ladle. The permitted deviations of any analysis of the product from those specified compositions are given in table 1. These deviations other than when maxima only are specified, apply either above *or* below the specified limits of the range, but not both above *and* below for the same element from different sample products from the same ladle. When maxima only are specified the deviations are positive only. Each of these lades will subsequently be regarded as a specified cast and identified accordingly. Samples for product analysis shall be taken in accordance with the requirements of BS 1837 : 1970.

Table 2. Permissible materials

Chemical and Physical properties	Type A	Type B	Type C	Type D
Carbon %	0.20 max.	0.18 max.	0.20 max.	0.20 max.
Silicon %	0.30 max.	0.25 max.	—	0.30 max.
Manganese %	0.60 max.	0.40 to 1.20	0.70 to 1.50	0.60 max.
Phosphorus %	0.05 max.	0.04 max.	0.050 max.	0.05 max.
Sulphur %	0.05 max.	0.04 max.	0.050 max.	0.05 max.
Niobium %	—	—	0.01 to 0.08	—
Yield stress (N/mm ²)	215 min.	275 min.	310 min.	200 min.
Tensile strength (N/mm ²)	340 to 430	400 to 490	430 to 510	320 to 420
Elongation %				
$L_0 = 50$ mm	28 min.	24 min.	21 min.	29 min.
$L_0 = 5.65 \sqrt{S_0}$	33 min.	29 min.	20 min.	35 min.
Bend test former radius	$1t_m^*$	$1.5t_m^*$	$1t_m^*$	$1t_m^*$

NOTE 1. Steels are to be balanced or killed.

NOTE 2. The mechanical properties quoted are those to be developed in the finished container.

NOTE 3. There are no equivalent steels to type A and type C in the current edition of BS 1449 : Part 1. Type A steel however is equivalent to classes HR 7B or C or HR 18B or C and type C is equivalent to classes HR 8B or C or HR 19B or C in BS 1449 : Parts 1A and 1B : 1962 (now withdrawn). Type B steel complies with the requirements of material FE 265KR of Euronorm 120.

* t_m is the minimum manufacturing thickness as specified on the drawing including corrosion allowance if any.

8. Permissible materials

8.1 Containers shall be made from the steels listed in table 2. These steels are particularly suitable for the manufacture of deep drawn containers.

8.2 The lowest permissible operating temperature in transport shall be atmospheric temperature.

9. Material for attachments subject to pressure

The Independent Inspecting Authority shall be satisfied that the material used in bungs and other pressure parts is suitable for such parts of the container.

Section three. Design

10. Service conditions for design

10.1 Where gases are to be conveyed in the United Kingdom in uninsulated containers, it shall be assumed that the most severe conditions of exposure to the climate will cause the contents to reach the developed pressure at the reference temperature specified in table 3, the values of which vary with the type of gas contained.

The maximum permissible pressure in service, to which the test pressure of the container is related (see 12.2), is the pressure developed by the contents at the pressure reference temperature, taking into account the filling ratio for high-pressure liquefiable gases, and the intended filled pressure at 15 °C for permanent gases. The necessary data on the relationship between filled pressure (and on filling ratio) and developed pressure at the reference temperature are given in BS 5355 : 1976.

Reference temperatures for filling ratios of low pressure liquefiable gases in uninsulated containers shall be 45 °C.

Table 3. Reference temperatures for developed pressure for conveyance in the United Kingdom in uninsulated containers

Type of contents	Reference temperature
Low pressure liquefiable gas	55 °C
High pressure liquefiable gas	52.5 °C*
Permanent gas	60 °C

10.2 The water capacity of a container for a liquefiable gas shall be not less than the intended maximum mass of contents divided by the filling ratio. The necessary data on the physical properties of the liquefiable gases are given in BS 5355 : 1976.

10.3 The internal volume of a container for a permanent gas shall be such as to provide a nominal gas content at 15 °C and 1013 mbar.

The charging pressure shall be controlled so as to ensure that the maximum developed pressure, at the pressure reference temperature, does not exceed the requirements specified in this British Standard.

10.4 When gases are being conveyed in insulated containers the reference temperatures quoted in table 3 do not apply.

The temperature which can be reached by their contents, the corresponding developed pressure required for design and the allowable mass of liquefiable gas are all conditional upon the intended degree of insulation proposed with or without the assistance of some form of refrigeration and upon the journey duration. In these cases the operational criteria for design shall be sought from HM Inspectors of Explosives.

11. Classification of containers

11.1 Class I. Containers shall be constructed to class I if either or both of the following criteria apply.

(a) They are used to contain permanent or high pressure liquefiable gases or gas mixtures (see table 4).

(b) They are to be used for the transport of toxic gas (see table 4).

11.2 Class IA. Construction to class IA is subject to the approval of the Independent Inspecting Authority and requires that the longitudinal and/or circumferential seams shall be made by a fully or semi automatic welding process which has been shown to produce welds free from unacceptable defects.

Containers may be constructed to class IA if they are to be used for the transport of the gases italicized in table 4 (i.e. those gases which are of moderate toxicity or which give a sensory warning of a slight escape) subject to HM Inspectors of Explosives indicating that they have no objection to the proposal. No objection will be raised if evidence is produced to show that the design concerned is satisfactory in all respects for the proposed service. Additional tests may be required in support of this evidence.

11.3 Class IB. Where class IA containers are used for corrosive gases (see table 4) and one or more pressure-containing welds are made in a single run they shall be designated as class IB containers.

11.4 Class IAC. Class IAC shall be exclusively for containers for dissolved acetylene.

11.5 Class II. Containers for which construction to classes I, IA, IB or IAC is not prescribed by 11.1, 11.2 or 11.3 may be constructed to class IIA or IIB.

11.5.1 Class IIA. Containers shall only be constructed to class IIA if the container does not possess a longitudinal seam, has outwardly dished ends and the distance (mm) between the nearest edge of any welded seam and the geometrical transition between the cylindrical portion and the dished ends is not less than $2\sqrt{D_i t_e}$ where D_i is the internal diameter of the container (mm) and t_e is the actual thickness of dished end (mm).

11.5.2 Class IIB. Containers for which construction to classes I, IA, IB or IAC is not prescribed by 11.1, 11.2, 11.3 or 11.4 and which do not comply with the requirements of 11.5.1 shall be constructed to class IIB.

12. Design of container shell

12.1 Nomenclature for the cylindrical part of the shell

t is the minimum wall thickness (mm), to resist internal pressure and external forces due to handling, but excluding any additional thickness for corrosion and other influences.

*When safety devices are fitted to carbon dioxide containers this reference temperature may be reduced to 50 °C.

Table 4. Classification of gases

Permanent gases	Liquefiable gases	
($T_c < -10^\circ\text{C}$)	High pressure ($-10^\circ\text{C} \leq T_c \leq 70^\circ\text{C}$)	Low pressure ($T_c > 70^\circ\text{C}$)
Air Argon Boron trifluoride* Carbon monoxide*† Coal gas*† Fluorine*‡ Helium Hydrogen† Methane (Natural gas and town gas excluding coal gas)† Neon Nitrogen Oxygen	Carbon dioxide Chlorotrifluoromethane (R.13) Bromotrifluoromethane (R.13B1) Ethane† Ethylene† Hydrogen chloride*‡ Nitrous oxide Sulphur hexafluoride	<i>Ammonia*</i> Boron trichloride*‡ Bromochlorodifluoromethane (R.12B1) Butadiene† Butane† Carbonyl chloride*‡ <i>Chlorine*‡</i> Chlorine trifluoride*‡ 1-Chloro-1, 1-difluoroethane (R.142b) 2-Chloro-1, 1, 1-trifluoroethane (R.133a) Chlorodifluoromethane (R.22) Chloropentafluoroethane (R.115) Cyanogen chloride* Cyclopropane † Dichlorodifluoromethane (R.12) Dichlorofluoromethane (R.21) 1, 2-Dichlorotetrafluoroethane (R.114) 1, 1-Difluoroethane (R.152a)† Dimethylamine† Dimethylether† Ethylamine† Ethyl chloride† <i>Ethylene oxide*†</i> Hydrogen cyanide*† Hydrogen fluoride*‡ Hydrogen sulphide*‡ <i>Isobutane†</i> Methyl bromide* <i>Methyl chloride*†</i> Monomethylamine† Nitrogen tetroxide*‡ <i>Nitrosyl chloride*‡</i> Octafluorocyclobutane (R.C318) Propane† Propylene† <i>Sulphur dioxide*‡</i> Trimethylamine† Vinyl chloride† <i>Gas mixtures</i> Azeotrope R.500 (73.8 % R.12 and 26.2 % R.152a) Azeotrope R.502 (48.8 % R.22 and 51.2 % R.115) <i>Ethylene oxide* 12 % and R.12 88 %</i>

*These gases are poisonous and are the ones referred to in this standard as toxic gases requiring special treatment. Other gases not so marked may have poisonous properties in less degree or be suffocating in heavy concentrations.

†For the purposes of transport these gases are considered to be flammable.

‡These gases are considered corrosive for the purpose of 11.3.

NOTE 1. T_c is the critical temperature.

NOTE 2. Reference to refrigerants by number designation (e.g. R.12) is in accordance with international agreements (see BS 4580 : 1970).

NOTE 3. Those gases italicized may, in accordance with 11.2, be conveyed in class 1A containers.

NOTE 4. The list is not intended to be comprehensive as other gases may be transported.

Table 5. Summary of classification of containers and of provisions according to class

Class no.	I	IA	IB	IAC	IIA	IIB
Application	Containers shall be constructed to class I if one or more of the following apply: (a) they contain any gas other than a low pressure liquefiable gas; (b) they contain a toxic gas (see table 4).	Containers shall only be in class IA if the welded seams are made by an automatic welding process which has been shown to produce welds free from unacceptable defects. Containers may be constructed to class IA if they are to contain one of the toxic gases italicized in table 4 subject to no objection being raised by HM Inspector of Explosives.	Containers shall be constructed to class IB if, in addition to the requirements for class IA being satisfied, the containers are to be used for corrosive gases (see table 4) and one or more pressure containing welds are made in a single run.	Containers shall be constructed to class IAC where they are to be used exclusively for dissolved acetylene. The requirements for class IA shall apply.	Unless construction to classes I, IA, IB or IAC is mandatory by the provisions of the previous four columns, containers may be constructed to classes IIA or IIB. A container may be constructed to class IIA if it does not possess a longitudinal seam, has outwardly dished ends and meets the prescribed distance between the weld seam and the tangent line of the adjacent end (see 11.5.1).	If the container does not meet the provisions of the previous column it shall be constructed to class IIB.
Stress reduction factors for walls of cylindrical or spherical containers	0.95	0.90	0.90	0.90	0.85	0.80
Mechanical tests on finished containers.	Mechanical tests on one in each batch of 202 finished containers.					
Radiographic examination of welds and repair of welds.	All containers to be radiographed. All repairs to be approved by the Independent Inspecting Authority and re-radiographed.	Initial examination and production checks required. All repairs to be approved by the Independent Inspecting Authority and re-radiographed.	All single run pressure containing welds to be fully radiographed.	The two test containers shall be fully radiographed. All repairs to be approved by the Independent Inspecting Authority and re-radiographed.	For containers with thicknesses 6 mm and above, one container per batch. For such containers all repairs to be approved by the Independent Inspecting Authority and re-radiographed.	
Batch size	202	202	202	202	402	402

- P_1 is the test pressure (bar) applicable to design governed by equations (1) and (4).
 P_2 is the test pressure (bar) applicable to design governed by equations (3) and (6).
 p is the pressure (bar) developed by the contents of a container at the pressure reference temperature.
 D_o is the external diameter of container (mm).
 D_i is the internal diameter of container (mm).
 f_e is the maximum permissible equivalent stress (N/mm^2) at test pressure ($= 0.75 \times$ minimum specified yield stress Y (N/mm^2) of the material of construction $\times$ appropriate stress reduction factor as given in table 7).
 T is the minimum specified tensile strength (N/mm^2) of the material of construction.
 Y is the minimum specified yield stress (N/mm^2) of the material of construction.

Values of Y , T and f_e are given in table 8 for the permissible materials.

12.2 Permissible pressure. The maximum pressure attainable in service by a permanent gas in an uninsulated container or liquefiable gas in an insulated container shall not exceed the lesser of:

- 0.90 of the test pressure; or
- 0.576 of the test pressure times the ratio of the minimum specified tensile strength to the minimum specified yield stress of the material of construction;

The maximum pressure attainable in service by a liquefiable gas in an uninsulated container shall not exceed the lesser of:

- the test pressure of the container; or
- 0.64 of the test pressure times the ratio of the minimum specified tensile strength to the minimum specified yield stress of the material of construction.

Table 6. Relationship between test pressure, pressure developed at the reference temperature and gas classification

Gas classification	Relationship between P_1 and p	
	$Y/T \leq 0.64$	$Y/T > 0.64$
Permanent gases in uninsulated containers, and liquefiable gases in insulated containers	$P_1 = \frac{p}{0.90}$	$P_1 = \frac{p}{0.90} \times \frac{Y}{0.64T}$ $= p \times \frac{Y}{0.576T}$
Low pressure and high pressure liquefiable gases in uninsulated containers	$P_1 = p$	$P_1 = p \frac{Y}{0.64T}$

12.3 Thickness of cylindrical wall. The thickness of the cylindrical wall of a container shall be not less than the value given by equation (1).

$$t = \frac{0.3 P_1 D_i}{7 f_e - P_1} \text{ or } t = \frac{0.3 P_1 D_o}{7 f_e - 0.4 P_1} \quad \dots (1)$$

except that the thickness of the cylindrical wall shall be not less than the value given by equation (2).

$$t = 2.48 \sqrt{\frac{D_i}{T}} \quad \dots (2)$$

Equation (2) will override equation (1) for comparatively low values of P_1 , in which case the test pressure P_2 shall be derived from equation (3).

$$P_2 = \frac{7 f_e}{1 + 0.12 \sqrt{D_i T}} \quad \dots (3)$$

In these circumstances it is permissible to reassess the pressure duty of the container within the maximum limitation obtained, by substitution of the values of P_2 for P_1 in table 6.

12.3.1 Acetylene containers. For containers for use with dissolved acetylene the test pressure P_1 shall be 52 bar in all circumstances.

12.4 Wall thickness of a spherical container. The thickness of the wall of a spherical container shall be not less than the value given by equation (4):

$$t = \frac{P_1 D_i}{40 f_e - 4.5 P_1} \text{ or } t = \frac{P_1 D_o}{40 f_e - 2.5 P_1} \quad \dots (4)$$

except that the thickness of the wall shall be not less than the values given by equation (5):

$$t = 1.65 \sqrt{\frac{D_i}{T}} \quad \dots (5)$$

Equation (5) will override equation (4) for comparatively low values of P_1 , in which case the test pressure P_2 shall be derived from equation (6):

$$P_2 = \frac{f_e \times 10^3}{112.5 + 15.2 \sqrt{D_i T}} \quad \dots (6)$$

In these circumstances it is permissible to reassess the pressure duty of the container, within the maximum limitation obtained by substitution of the value of P_2 for P_1 in table 6.

Table 7. Stress reduction factors for the cylindrical part of the shell

Class of container	Stress reduction factor
Class I	0.95
Classes IA, IB and IAC	0.90
Class IIA	0.85
Class IIB	0.80

The factors in table 7 are not valid for containers to be subjected to a large number of fluctuations of pressure. It is recommended that HM Inspector of Explosives should be consulted regarding the design of any container which is expected to be charged more than 10 000 times in the course of its life.

12.5 Domed ends

12.5.1 Nomenclature for ends

t is the minimum wall thickness of the cylindrical shell (mm) to resist internal pressure and external forces due to handling, but excluding any additional thickness for corrosion and other influences (see 12.3).

t_e is the minimum wall thickness of ends (mm) to resist internal pressure and external forces due to handling, but excluding any additional thickness for corrosion and other influences.