

Transportable gas containers —

**Part 2: Specification for steel containers
of 0.5 L up to 450 L water capacity with
welded seams**

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Pressure Vessel Standards Policy Committee (PVE/-) to Technical Committee PVE/3, upon which the following bodies were represented:

- Aluminium Federation
- Associated Offices Technical Committee
- Association of Manufacturers of Domestic Electrical Appliances
- British Compressed Gases Association
- British Fire Consortium
- British Fire Protection Systems Association Ltd.
- British Railways Board
- British Soft Drinks Association Ltd.
- Chief and Assistant Chief Fire Officers' Association
- Department of Trade and Industry [Mechanical Engineering and Manufacturing Technology Division (Mmt)]
- Department of Trade and Industry (National Engineering Laboratory)
- Department of Trade and Industry (National Physical Laboratory)
- Department of Transport (Marine Directorate)
- Engineering Equipment and Materials Users' Association
- Fire Extinguishing and Trades Association
- Health and Safety Executive
- Home Office
- Industrial Safety (Protective Equipment) Manufacturers' Association
- Institute of Refrigeration
- Institution of Chemical Engineers
- Liquefied Petroleum Gas Industry Technical Association (UK)
- Metal Packaging Manufacturers' Association
- Ministry of Defence
- Society of Motor Manufacturers and Traders Limited
- Coopted members

The following body was also represented in the drafting of the standard, through subcommittees and panels:

Welding Institute

This British Standard, having been prepared under the direction of the Pressure Vessels Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 31 October 1989

© BSI 01-1999

First published October 1974
First revision May 1978
Second revision October 1989

The following BSI references relate to the work on this standard:
Committee reference PVE/3
Draft for comment 84/75994 DC

ISBN 0 580 17314 3

Amendments issued since publication

Amd. No.	Date of issue	Comments
6319	January 1991	
7911	October 1993	Indicated by a sideline in the margin

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
Section 1. General	
1 Scope	1
2 Manufacture and testing of containers	1
3 Classification of gases	1
4 Information to be supplied by the purchaser and the manufacturer	1
5 Certificate of compliance	4
Section 2. Permissible materials	
6 Materials for pressure parts	5
7 Material for attachments	5
Section 3. Design	
8 Service conditions for design	7
9 Classification of containers	7
10 Design of container shell	9
11 Openings and branch connections	15
12 Fittings	15
Section 4. Manufacture and workmanship	
13 Approval of design and construction details	17
14 Tolerances	17
15 Welds	17
16 Heat treatment	17
Section 5. Inspection and tests	
17 Inspection of components	18
18 Test requirements	18
19 Mechanical tests	19
20 Hydraulic tests	23
21 Hydraulic bursting test	25
22 Checking of water capacity	25
23 Tightness test	25
24 Prototype fatigue tests	25
25 Radiographic examination of welds	26
26 Repair of welds	27
27 Results of mechanical and pressure tests	27
28 Final internal inspection	27
Section 6. Marking of containers	
29 Information to be marked	28
30 Method of marking	28
Appendix A Hydraulic proof pressure test	29
Appendix B Hydraulic volumetric expansion test	29
Appendix C Example of design procedure	36
Appendix D Specimen certificate of compliance for welded steel gas containers	38
Figure 1 — Shape factor K	12
Figure 2 — Domed ends	14
Figure 3 — Location of test specimens in a container	21

	Page
Figure 4 — Reduced section tensile test specimen	24
Figure 5 — Nick-break test specimen	24
Figure 6 — Example of hydraulic proof pressure test equipment	30
Figure 7 — Water jacket volumetric expansion test (levelling burette)	31
Figure 8 — Water jacket volumetric expansion test (fixed burette)	33
Figure 9 — Non-water jacket volumetric expansion test	34
Table 1 — Classification of gases	3
Table 2 — Permissible materials	6
Table 3 — Permissible deviations on product analysis	6
Table 4 — Reference temperatures for developed pressure for conveyance in the UK in uninsulated containers	7
Table 5 — Classification and construction criteria	8
Table 6 — Stress reduction factors for walls of cylindrical or spherical containers	9
Table 7 — Formulae for deriving minimum values of test pressure	11
Table 8 — Ratio n between the diameter of the former and the thickness of the bend test specimen	23
Table 9 — K factors for the compressibility of water	35
Publications referred to	Inside back cover

Foreword

This Part of BS 5045 has been prepared under the direction of the Pressure Vessel Standards Policy Committee and deals with materials, design, construction and testing of new containers intended for the conveyance by road of permanent, liquefiable and dissolved gases, under pressure.

This revision supersedes BS 5045-2:1978 which is withdrawn. This Part was originally published in 1974, covering steel containers having mechanized welded circumferential seams only. The 1978 revision was made to incorporate containers with both longitudinal and circumferential seams and to make it applicable to containers for dissolved acetylene. This revision incorporates a prototype test, clarifies the classification of containers and updates other requirements as dictated by experience.

The BS 5045 series is being prepared in a number of Parts to cover the various forms of manufacture. Those Parts published or in preparation are as follows:

- *Part 1: Specification for seamless steel gas containers above 0.5 litre water capacity;*
- *Part 3: Specification for seamless aluminium alloy gas containers above 0.5 litre water capacity and up to 300 bar charged pressure at 15 °C;*
- *Part 5: Specification for aluminium alloy containers above 0.5 litre up to 130 litres water capacity with welded seams;*
- *Part 6: Specification for seamless containers of less than 0.5 litre water capacity.*

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

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 40, an inside back cover and a back cover.

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

Section 1. General

1 Scope

This Part of BS 5045 specifies requirements for the materials, design, construction and testing of containers for the conveyance of permanent, liquefiable and dissolved gases under pressure; such containers are suitable also for storing gas under pressure. It applies to steel containers of water capacity of 0.5 L up to 450 L having longitudinal and/or circumferential main seams, made up mechanized arc welding.

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.

It does not cover the design and manufacture of portable fire extinguishers where the developed pressure of the contents does not exceed 25 bar¹⁾ at the appropriate reference temperature; these are specified in BS 5423.

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

2 Manufacture and testing of containers

The manufacture, inspection and testing of containers shall be carried out to the satisfaction of an Independent Inspecting Authority to be approved by the Health and Safety Executive.

3 Classification of gases

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

- a) *Permanent gases*. Those gases that have a critical temperature below $-10\text{ }^{\circ}\text{C}$.
- b) *Liquefiable gases*. Those gases that are liquefiable by pressure at $-10\text{ }^{\circ}\text{C}$ but that are completely vaporized at $17.5\text{ }^{\circ}\text{C}$ when at 1 013 mbar.
 - 1) *High pressure liquefiable gases*. Those gases that have a critical temperature between $-10\text{ }^{\circ}\text{C}$ and $70\text{ }^{\circ}\text{C}$ inclusive.
 - 2) *Low pressure liquefiable gases*. Those gases that have a critical temperature above $70\text{ }^{\circ}\text{C}$.

Any toxic substance that is liquid at $0\text{ }^{\circ}\text{C}$ at 1 013 mbar pressure, but that is completely vaporized at or below $30\text{ }^{\circ}\text{C}$ when at that pressure, is treated as a low pressure liquefiable gas.

c) *Dissolved gases*. Those gases that are dissolved under pressure in a solvent contained in a porous substance at ambient temperature and that are released from the solvent without the application of heat.

Gases that are currently conveyed in commercial quantities are classified in Table 1.

4 Information to be supplied by the purchaser and the manufacturer

4.1 Information to be supplied by the purchaser

The following information to be supplied by the purchaser shall be fully documented, and together with the definitive requirements specified throughout the standard, shall be satisfied before a claim of compliance with this can be made and verified:

- a) name or classification of gas(es);
- b) class of construction (e.g. BS 5045-2, class 1A);
- c) volumetric capacity (minimum for liquefiable gases);
- d) for permanent gases, the filling pressure at $15\text{ }^{\circ}\text{C}$;
- e) for liquefiable gases, the mass of gas or filling ratio at the prescribed reference temperature or the required developed pressure in service;
- f) material of construction;
- g) preferred dimensions;
- h) shape of base;
- i) internal and/or external neck screwing dimensions;
- j) fittings required, including set pressure and flow rate of any pressure relief devices;
- 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) any requirements in addition to those specified in this Part of BS 5045;
- n) name of the independent inspecting authority.

¹⁾ 1 bar = 10^5 N/m^2 = 100kPa.

4.2 Information to be supplied by the manufacturer

The following information to be supplied by the manufacturer shall be fully documented, and together with the definitive requirements specified throughout the standard, shall be satisfied before a claim of compliance with the standard can be made and verified:

- a) fully dimensioned sectional drawing of the container including:
 - 1) name or classification of gas(es);
 - 2) volumetric capacity (minimum for liquefiable gases);
 - 3) filling pressure at 15 °C for permanent gas(es) or mass of liquefiable gas(es);
 - 4) material of construction;
 - 5) test pressure;
 - 6) minimum and maximum masses of container;
 - 7) statement that the container will be constructed to the requirements of this standard;
 - 8) design approval reference (see clause 13);
 - 9) corrosion allowance (if any);
 - 10) large scale dimensional details of weld preparation for all seams and details of the joints;
- b) fittings to be supplied including set pressure and flow rate of any pressure relief device;
- c) drawing showing layout of container marking, including set pressure and flow rate of any pressure relief device;
- d) a statement which permits access at all reasonable times by the independent inspecting authority to that part of the manufacturer's works engaged upon the order, for the purpose of inspecting the fabrication of the containers at any stage;
- e) a statement that the manufacturer shall supply labour and appliances for the inspection and tests required;
- f) an undertaking to give an agreed period of notice to the independent inspecting authority of when the containers will reach a stage at which the inspection and/or test is required;
- g) certificate of compliance for materials and container (see Appendix D).

Table 1 — Classification of gases

Permanent gases ($T_c < -10\text{ °C}$)	Liquefiable gases		Dissolved gases
	High pressure ($-10\text{ °C} \leq T_c \leq 70\text{ °C}$)	Low pressure ($T_c > 70\text{ °C}$)	
Air Argon Boron trifluoride ^a Carbon monoxide ^{ab} Carbon tetrafluoride (R.14) Coal gas (including coke oven gas) ^a Deuterium ^b Fluorine ^{ab} Helium Hydrogen ^b Krypton Methane (natural gas) ^b Neon Nitrogen Oxygen Town gas (excluding coal gas) ^{ab} Xenon	Bromotrifluoromethane (R.13B1) Carbon dioxide Chlorotrifluoromethane (R.13) Diborane ^a 1, 1-Difluoroethylene (R.1132a) Ethane ^b Ethylene ^b Hexafluoroethane (R.116) Hydrogen chloride ^{ac} Nitric oxide Nitrous oxide Phosphine ^a Silane ^a Sulphur hexafluoride Trifluoromethane (R.23)	Allene ^b <i>Ammonia</i> ^a Arsine ^{ab} Boron trichloride ^a Bromochlorodifluoromethane (R.12B1) Butadiene ^b Butane ^b 1-Butene ^b 2-Butene ^b Carbonyl chloride ^{ac} Carbonyl sulphide ^{ac} <i>Chlorine</i> ^{ac} Chlorine trifluoride ^{ac} 1-Chloro-1, 1-difluoroethane (R.142b) ^b Chlorodifluoromethane (R.22) Chloropentafluoroethane (R.115) 2-Chloro-1,1,1-trifluoroethane (R.133a) Cyanogen ^{ab} Cyanogen chloride ^a Cyclopropane ^b Dichlorodifluoromethane (R.12) Dichlorofluoromethane (R.21) 1,2-Dichlorotetrafluoroethane (R.114) 1,1-Difluoroethane (R.152a) ^b Dimethylamine ^b Dimethyl ether ^b 2,2-Dimethyl propane ^b Ethylacetylene ^b Ethylamine ^b Ethyl chloride ^b <i>Ethylene oxide</i> ^{ab} Hexafluoropropene Hydrogen cyanide ^{ab} Hydrogen fluoride ^{ac} Hydrogen selenide Hydrogen sulphide ^{ac} Isobutane ^b Isobutylene ^b Methyl acetylene ^b Methylamine ^b Methyl bromide ^{ab} 3-Methyl-1-butene ^b <i>Methyl chloride</i> ^{ab} Methyl mercaptan ^{ab} Monomethylamine ^b	Acetylene ^b

Table 1 — Classification of gases

Permanent gases ($T_c < -10\text{ °C}$)	Liquefiable gases		Dissolved gases
	High pressure ($-10\text{ °C} \leq T_c \leq 70\text{ °C}$)	Low pressure ($T_c > 70\text{ °C}$)	
		Nitrogen dioxide ^a Nitrogen tetroxide ^a Nitrogen trioxide ^a <i>Nitrosyl chloride</i> ^{ac} Octafluorocyclobutane (R.C318) Perfluoropropane Propane ^b Propylene ^b <i>Sulphur dioxide</i> ^{ac} Trimethylamine ^b Vinyl bromide ^a Vinyl chloride ^b Vinyl fluoride ^b Vinyl methyl ether ^b Gas mixtures: 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</i> ^a 12 % and R.12 88 %	

^a 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 a lesser degree or be suffocating in heavy concentrations.

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

^c These gases are considered corrosive for the purpose of 9.2.

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).

NOTE 3 Those gases italicized may, in accordance with 9.2.2, be conveyed in class IA or class IB or class I containers.

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

NOTE 5 Halogenated hydrocarbon gases used for fire-fighting purposes are referred to by the halon numbering system. Under this system the two most commonly used gases for fire-fighting purposes, bromochlorodifluoromethane (CF_2ClBr) and bromotrifluoromethane (CF_3Br), are designated Halon 1 211 and Halon 1 301, respectively. Halon 1 211 is also known as BCF and Halon 1 301 is also known as BTM. Both substances are also refrigerant gases, and are designated R.12B1 and R.13B1 respectively when used for refrigeration purposes.

5 Certificate of compliance

The manufacturer shall certify that the manufacture, inspection and testing of the container were carried out in compliance with this standard.

The independent inspecting authority shall certify acceptance of the above certification.

NOTE A model form of certificate is shown in Appendix D.

Section 2. Permissible materials

6 Materials for pressure parts

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

6.2 The materials shall be suitable for use at the lowest permissible operating temperature in transport which shall be atmospheric temperature.

6.3 Sheet and plate material used for containers shall be balanced or killed steel in accordance with Table 2 or, subject to the agreement of the independent inspecting authority, steel as specified in Euronorm 120.

The mechanical properties of the finished containers shall be in accordance with Table 2. The yield stress shall be the lower yield stress, except that where a distinct yield is not apparent, the value shall be the 0.2 % proof stress.

6.4 Steels used for bungs and other pressure parts of containers shall be balanced or killed and shall be suitable for welding to the steels given in Table 2.

6.5 Each bundle or coil shall be identified for use in containers manufactured in accordance with BS 5045-2 and shall be marked with the type letter (see Table 2) or other identification mark 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.

6.6 The container manufacturer shall ensure that the steel supplier has provided an appropriate manufacturer's certificate with each batch of steel giving details of ladle analysis and mechanical properties.

6.7 The ladle analysis of materials shall be within the specified composition limits. 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 ladle analysis of the product from those specified compositions shall be as given in Table 3. These deviations, other than when maxima only are specified, shall apply either above or below the specified limits of the range, but not both above and below for the same element from different samples from the same ladle. When maxima only are specified the deviations shall be positive only.

Each ladle shall subsequently be regarded as a specified cast and identified accordingly.

Samples for product analysis shall be taken in accordance with BS 1837.

7 Material for attachments

The independent inspecting authority shall be satisfied that the material used in attachments is suitable in all respects, including weldability where relevant.

Table 2 — Permissible materials

Chemical and physical properties	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Carbon % max.	0.20	0.18	0.20	0.20	0.15	0.18	0.25
Silicon % max.	0.30	0.25	—	0.30	0.30	0.40	0.35
Manganese % min.	—	0.40	0.70	—	—	0.50	0.60
% max.	0.60	1.20	1.50	0.60	1.20	1.40	1.40
Phosphorus % max.	0.05	0.04	0.05	0.05	0.025	0.04	0.03
Sulphur % max.	0.05	0.04	0.05	0.05	0.030	0.04	0.045
Grain refining elements % max	—	—	— ^a	—	0.30 ^a	—	0.70
Yield stress (N/mm ²) min	215	275	310	200	350	285	250
Tensile strength (N/mm ²) min.	340	400	430	320	430	430	430
Tensile strength (N/mm ²) max.	430	490	585	420	650	510	550
Elongation % min. ^b							
$L_0 = 50$ mm	28	24	21	29	21	—	21
$L_0 = 5.65 \sqrt{S_0}$	33	29	20	35	25	20	25

^a Grain refining elements are limited to: niobium 0.08 %, titanium 0.20 %, vanadium 0.20 %, niobium plus vanadium 0.20 %.

^b Where any other non-proportional gauge lengths are used, conversions are in accordance with BS 3894-1.

NOTE 1 L_0 is the original gauge length.
 S_0 is the original cross-sectional area.

NOTE 2 Type A and type C are equivalent to grades of BS 1449:1962 (withdrawn); type E is equivalent to grade 43/35 of BS 1449-1; type D is similar to Euronorm 120; type G is equivalent to type 151 grade 430 of BS 1501-1.

Table 3 — Permissible deviations on product analysis

Element	Specified range	Permissible deviation ^a on product analysis
	%	%
Carbon	≤ 0.25 > 0.25	0.02 0.03
Silicon	≤ 0.60	0.05
Manganese	≤ 1.0 > 1.0	0.08 0.10
Phosphorus	≤ 0.050	0.010
Sulphur	≤ 0.050	0.010
Niobium	≤ 0.10	0.02

^a Maximum and minimum values do not apply simultaneously for individual elements (see 6.7).

Section 3. Design

8 Service conditions for design

8.1 Where gases are to be conveyed in the UK 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 4, 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 10.2), shall be 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 charged pressure at 15 °C for permanent gases.

NOTE The necessary data on the relationship between charged pressure (and on filling ratio) and developed pressure at the reference temperature are given in BS 5355.

The reference temperature for filling ratios of low pressure liquefiable gases in uninsulated containers shall be 45 °C.

Table 4 — Reference temperatures for developed pressure for conveyance in the UK in uninsulated containers

Type of contents	Reference temperature
	°C
Low pressure liquefiable gas	55
High pressure liquefiable gas	52.5 ^a
Permanent gas	60
^a When safety devices are fitted to carbon dioxide containers, this reference temperature may be reduced to 50 °C.	

8.2 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.

NOTE The necessary data on the physical properties of the liquefiable gases are given in BS 5355.

8.3 The internal volume of a container for a permanent gas shall be such as to provide a nominal gas content which at 15 °C will have a developed pressure of 1 013 mbar.

The charged pressure shall be specified to ensure that the maximum developed pressure at the pressure reference temperature does not exceed the requirements specified in this standard.

8.4 when gases are to be conveyed in insulated containers the operational criteria for design shall be sought from the independent inspecting authority.

NOTE 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.

8.5 For containers used for fire-fighting purposes filled with halons and dry nitrogen the developed pressure requirements shall conform to the appropriate Part of BS 5306.

Containers intended to contain carbon dioxide as the fire extinguishant shall conform to the developed pressure and filling ratio requirements of BS 5355 and BS 5423.

9 Classification of containers

9.1 Classification by construction

9.1.1 General. Containers shall be constructed to one of the following classes, depending on their intended application (see 9.2 and Table 5):

- a) class I
- b) class IA, IB, IAC
- c) class IIA, IIB

The different construction criteria for each class (i.e. batch size for testing, degree of radiography, stress reduction factor) shall be as specified in 18.1.1, clause 25 and Table 6 respectively.

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

Class II containers not eligible for class IIA construction shall be made to class IIB.

9.2 Relationship of classification to contents

NOTE Class II containers constructed to class IIA or class IIB may be used whenever construction to classes I, IA, IB or IAC is not prescribed by 9.2.1, 9.2.2 or 9.2.3.

9.2.1 Permanent gases and high pressure liquefiable gases

9.2.1.1 When the gas(es) is (are) not toxic, flammable or corrosive, and the developed pressure at 55 °C is less than 75 bar but more than 25 bar they shall be carried in class IA, class IB or class I containers; when the developed pressure is less than 25 bar, class II containers shall be allowable.

9.2.1.2 In all other cases the gases shall be carried in class I containers.

9.2.2 Toxic gases

NOTE See Table 1.

9.2.2.1 The non-corrosive toxic gases italicized in Table 1 (i.e. those gases which are of moderate toxicity or which give sensory warning of a slight escape) shall be carried in class IA, class IB or class I containers.

9.2.2.2 The corrosive toxic gases italicized in Table 1 shall be carried in class IB or class I containers.

9.2.2.3 All other toxic gases or their mixtures shall be carried in class I containers.

9.2.3 Acetylene. Class IAC containers shall be used exclusively for dissolved acetylene (see 13.2).

Table 5 — Classification and construction criteria

Classification by content		Classification of container (see note 1)					
		I	IA	IB	IAC	IIA	IIB
Toxic gases (see 9.2.2.3)		X					
Corrosive toxic gas: moderate toxicity (see 9.2.2.2)		X		X			
Non-corrosive toxic gas: moderate toxicity (see 9.2.2.1)		X	X	X			
Permanent and liquefiable gas having a developed pressure greater than 75 bar at 55 °C: including mixtures (see 9.2.1.2)		X					
Permanent and liquefiable gas and having a developed pressure between 75 bar and 25 bar at 55 °C. Including mixtures (see 9.2.1.1)		X	X (see note 2)	X			
Acetylene (see 9.2.3)					X		
Non-toxic non-corrosive gases having a developed pressure lower than 25 bar at 55 °C (see note to 9.2)						X (see 9.1.2)	X
Construction criteria							
Radiographic examination of welds at manufacture	Full	X					
	Sample		X	X (see note 3)	X		
	None					X (see note 4)	X
Radiographic examination of weld repairs (see note 5)	Full	X	X	X	X		
	None					X (see note 6)	X
NOTE 1 Classifications shown are minimum. Gases can be conveyed in containers of higher class than specified. NOTE 2 Applicable only to gases which are non-toxic, non-corrosive and non-flammable. NOTE 3 Class IB containers should either have all pressure containing welds made with a double run; or all pressure containing welds made in a single run should be radiographed. NOTE 4 Sample radiography is only required for weld thicknesses 6 mm or above. NOTE 5 All repairs are to be approved by the independent inspecting authority. NOTE 6 All repairs of weld thicknesses 6 mm or above are to be radiographed.							

Table 6 — Stress reduction factors for walls of cylindrical or spherical containers

Class of container	Stress reduction factor
I	0.95
IA, IB and IC	0.90
IIA	0.85
IIB	0.80
NOTE The stress reduction factors are not valid for containers to be subjected to a large number of fluctuations of pressure. It is recommended that prototype tests, see clause 24, should prove the design of a container which is expected to be charged more than 10 000 times in the course of its life.	

10 Design of container shell

10.1 Nomenclature for the cylindrical part of the shell

- t is the minimum wall thickness (in mm) to resist internal pressure and external forces due to handling, but excluding any additional thickness for corrosion and other influences;
- P_1 is the test pressure (in bar) applicable to design governed by equations (1) and (4);
- P_2 is the test pressure (in bar) applicable to design governed by equation (3);
- p is the pressure (in bar) developed by the contents of a container at the pressure reference temperature;
- D_o is the external diameter of the container (in mm);
- D_i is the internal diameter of the container (in mm);
- f_e is the maximum permissible equivalent stress (in N/mm²) at test pressure ($= 0.75 \times$ minimum specified yield stress Y of the material of construction $\times$ appropriate stress reduction factor as given in the Table 6);
- T is the minimum specified tensile strength (in N/mm²) of the material of construction;
- Y is the minimum specified yield stress (in N/mm²) of the material of construction.

10.2 Derivation of test pressure

Test pressure is defined as the pressure used to calculate minimum wall thickness (t), and the pressure at which hydraulic testing is carried out.

Test pressure P_1 is deduced in terms of the container's contents and the material of construction. Test pressure P_2 is applicable only to those containers whose minimum wall thickness is governed by equation (3).

Test pressure P_1 is derived from a consideration of:

a) the maximum pressure (p) developed in service by the gaseous contents at the nominated reference temperature as given by BS 5355;

b) the yield and tensile (Y and T) properties of the container material as given in Table 2.

Table 7 specifies formulae to be used for deriving minimum values of test pressure P_1 applicable to the various gas classifications.

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

10.3 Thickness of cylindrical wall

The thickness of the cylindrical wall of a container shall be not less than the values given by equation (1):

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

except that the thickness of the cylindrical wall determined by equation (1) shall be not less than the value given by equation (2):

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

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):

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

NOTE 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 7.

10.4 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):

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

except that the thickness of the wall determined by equation (4) shall be not less than the value given by equation (2).

Equation (2) will override equation (4) for comparatively low values of P_1 , in which case the test pressure P_2 shall be derived from equation (3).

NOTE 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 7.