

Transportable gas containers —

**Part 5: Specification for aluminium
alloy containers above 0.5 litre up
to 130 litres water capacity with welded
seams**

UDC 621.772.43:66.076.5:621.642.2.02:669.715

Committees responsible for this British Standard

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

- Aluminium Federation
- Associated Offices Technical Committee
- Association of Drum Manufacturers
- Association of Manufacturers of Domestic Electrical Appliances
- British Compressed Gases Association
- British Fire Protection Systems Association Ltd.
- British Railways Board
- British Sub-aqua Club
- Chief and Assistant Chief Fire Officers' Association
- Department of Trade and Industry (Mechanical and Electrical Engineering Division)
- 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 Trades Association
- Health and Safety Executive
- Home Office
- Industrial Safety (Protective Equipment) Manufacturers' Association
- Institute of Refrigeration
- Institution of Chemical Engineers
- Institution of Fire Engineers
- Liquefied Petroleum Gas Industry Technical Association (UK)
- Ministry of Defence
- Motor Industry Research Association
- National Association of Soft Drinks Manufacturers
- Society of Motor Manufacturers and Traders Limited
- Coopted members

The following was also represented in the drafting of the standard, through sub-committees and panels:

Coopted member

This British Standard, having been prepared under the direction of the Pressure Vessel Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 July 1986

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The following BSI references relate to the work on this standard:
Committee reference PVE/3
Draft for comment 81/73542 DC

ISBN 0 580 14483 6

Amendments issued since publication

Amd. No.	Date of issue	Comments
6321	January 1991	Indicated by a sideline in the margin

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Foreword

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

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

- *Part 1: Specification for seamless steel gas containers above 0.5 litre water capacity;*
- *Part 2: Steel containers up to 130 litres water capacity with welded seams;*
- *Part 3: Specification for seamless aluminium alloy containers above 0.5 litre water capacity and up to 300 bar charged pressure at 15 °C;*
- *Part 4: Specification for steel containers of over 450 litres water capacity with circumferential and longitudinal welded seams¹⁾;*
- *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 up to and including 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 36, an inside back cover and a back cover.

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

¹⁾ In preparation.

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 gases under pressure; such containers are suitable also for storing gas under pressure. It applies to aluminium alloy containers of water capacity above 0.5 litre up to 130 litres having longitudinal and/or circumferential seams, made by mechanized TIG or MIG 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 bar²⁾ 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.

3 Classification of gases

3.1 General

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

- a) *Permanent gas*. A gas that has a critical temperature below $-10\text{ }^{\circ}\text{C}$.
- b) *Liquefiable gas*. A gas that is liquefiable by pressure at $-10\text{ }^{\circ}\text{C}$ but which is completely vapourized below $17.5\text{ }^{\circ}\text{C}$ when at 1 013 mbar²⁾.
 - 1) *High pressure liquefiable gas*. A gas that has a critical temperature from $-10\text{ }^{\circ}\text{C}$ to $70\text{ }^{\circ}\text{C}$ inclusive.
 - 2) *Low pressure Liquefiable gas*. A gas that has a critical temperature above $70\text{ }^{\circ}\text{C}$.

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

Gases that may be contained in aluminium alloy containers are classified in Table 1.

3.2 Gases that shall not be contained in aluminium alloy containers

Subject to the exception stated, the following gases shall not be contained in aluminium alloy containers. Certain of these gases may however be contained in aluminium alloy containers in small quantities as components of gas mixtures. Approval for such use shall be sought from the Health and Safety Executive.

acetylene
boron trifluoride
bromotrifluoroethylene
carbonyl chloride
chlorine
chlorine trifluoride
cyanogen chloride
fluorine
hydrogen bromide
hydrogen chloride
hydrogen fluoride
methyl bromide
methyl chloride
nitrosyl chloride

3.3 Unlisted gases

For conditions pertaining to the carriage in aluminium alloy containers of a gas not listed in Table 1 or 3.2, reference shall be made to the Health and Safety Executive.

4 Information to be supplied by the purchaser and the manufacturer

4.1 Information to be supplied by the purchaser

It is essential that the purchaser supplies the manufacturer with the following information as appropriate:

- a) name or classification of gas(es);
- b) class of construction (e.g. BS 5045-5, class IA);
- c) volumetric capacity (minimum for liquefiable gases);
- d) for permanent gases, the charged 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) materials of construction;
- g) preferred dimensions;
- h) type of base;

²⁾ 1 bar = $10^5\text{ N/m}^2 = 10^5\text{ Pa}$.

- 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.

4.2 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:
 - 1) name or classification of gas(es);
 - 2) volumetric capacity (minimum for liquefiable gases);
 - 3) charged pressure at 15 °C for permanent gas(es) or mass of liquefiable gas(es);
 - 4) materials 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) amount of corrosion allowance (if any);
 - 10) large scale dimensional details of the weld preparation for all seams and details of these joints;
- b) fittings to be supplied;
- c) marking arrangement drawing;
- d) certificate of compliance for materials and container.

5 Certificate of compliance

5.1 The Independent Inspecting Authority, to be approved by the Health and Safety Executive, 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.

5.2 The Independent Inspecting Authority shall indicate on the certificate that inspection and testing has been carried out in accordance with the requirements of this standard and, when applicable, with the procedures for testing for limited production (see 18.4).

5.3 When a batch consists of containers of various lengths (see 18.4.1), certificates shall be issued for each size of container within the batch.

Table 1 — Classification of gases suitable for conveyance in welded aluminium alloy containers

Permanent gases ($T_c < -10\text{ °C}$)	Liquefiable gases	
	High pressure ($-10\text{ °C} \leq T_c \leq 70\text{ °C}$)	Low pressure ($T_c > 70\text{ °C}$)
Air Argon Carbon monoxide ^{ab} Carbon tetrafluoride (R14) Coal gas ^{ab} Deuterium ^a Helium Hydrogen ^a Krypton Methane (natural gas) ^a Neon Nitrogen Oxygen Town gas (excluding coal gas) ^{ab} Xenon	Bromotrifluoromethane (R13B1) Carbon dioxide Chlorotrifluoromethane (R13) Diborane ^{bc} 1,1-Difluoroethylene (R1132a) ^a Ethane ^a Ethylene ^a Hexafluoroethane (R116) Nitric oxide Nitrous oxide Phosphine ^b Silane Sulphur hexafluoride Trifluoromethane (R23)	Allene ^a <i>Ammonia</i> ^b Arsine ^{ab} Bromochlorodifluoromethane (R12B1) Butadiene ^a Butane ^a 1 Butene ^a 2 Butene ^a Carbonyl sulphide ^{ab} 1-Chloro-1, 1-difluoroethane ^a (R142b) Chloropentafluoroethane (R115) 2-Chloro-1, 1, 1-trifluoroethane (R133a) Cyanogen ^{ab} Cyclopropane ^a Dichlorodifluoromethane (R12) Dichlorofluoromethane (R21) 1,2-Dichlorotetrafluoroethane (R114) 1,1-Difluoroethane ^a (R152a) Dimethylamine ^{ad} Dimethyl ether ^a 2,2 Dimethyl propane ^a Ethyl acetylene ^a Ethylamine ^{ad} Hexafluoropropene Hydrogen cyanide ^{ab} Hydrogen selenide Hydrogen sulphide ^{ab} Isobutane ^a Isobutylene ^a Methyl acetylene ^{abd} Methylamine ^a 3 Methyl-1-butene ^a Methyl mercaptan ^{ab} Nitrogen dioxide ^b Nitrogen tetroxide ^b Nitrogen trioxide ^b Octafluorocyclobutane (RC318) Perfluoro-2-butene ^b Perfluoro propane Propane ^a Propylene ^a <i>Sulphur dioxide</i> ^b Trimethylamine ^{ad} Vinyl bromide ^{be} Vinyl chloride ^{ae} Vinyl fluoride ^{ae} Vinyl methyl ether ^a Gas mixtures: Azeotrope R500 (73.8 % R12 and 26.2 % R152a) Azeotrope R502 (48.8 % R22 and 51.2 % R115)

NOTE 1 T_c in the column headings is the critical temperature.

NOTE 2 Gas mixtures may contain small fractions of other gases, and/or liquid components. The filler should ascertain that these mixtures are compatible with aluminium alloys under all normal conditions of use.

NOTE 3 All gases contained in aluminium containers are to be free from reactive halogens.

NOTE 4 Those gases italicized may in accordance with 9.3 be contained in class IA containers.

^a For the purpose of transport, these gases are considered to be flammable.

^b 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.

^c Normally only available as a component of a mixture.

^d Special care is necessary to ensure that these gases are dry to less than 20 vpm of moisture.

^e As a mixture component only up to 1 % by volume of total cylinder contents.

Section 2. Materials

6 General

- 6.1** The materials used for the container 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 marked and records shall be kept so as to enable the cast(s) from which a container is made to be identified.
- 6.3** The container manufacturer shall obtain from the aluminium alloy producer a certificate giving details of cast analysis and mechanical properties in the as supplied condition.
- 6.4** The cast shall be considered to be:
- a) the product of one furnace melt; or
 - b) the product of one crucible melt; or
 - c) the product of a number of crucible or furnace melts mixed prior to casting; or
 - d) the amount of metal having been made (when a continuous melting process is employed); or
 - e) as may be otherwise defined by the Independent Inspecting Authority.
- 6.5** The product analysis and the cast analysis shall be within the composition limits given in Table 2.

7 Permissible materials for container

7.1 Cylindrical shells and dished ends

Containers shall be made from either of types A and B materials given in Table 2. Mechanical properties of finished containers shall be in accordance with the values given in Table 3.

- NOTE** Type A is equivalent to material 6082 in the BS 1470 series and the following may be used:
- | | |
|---------|------|
| BS 1470 | 6082 |
| BS 1471 | 6082 |
| BS 1474 | 6082 |
- 7.2 Valve plates, bungs and bosses**
- The material used shall be either of types A and B given in Table 2 and Table 3.
- NOTE** For type A the following British Standard alloys may be used:
- | | |
|---------|------|
| BS 1470 | 6082 |
| BS 1472 | 6082 |
| BS 1474 | 6082 |
- 7.3 Materials for welded integral non-pressure parts**
- The material used shall be selected from one of the types A, B or C given in Table 2 and Table 3.
- NOTE** BS 1474 6063 meets the requirements of type C, and for type A the following British Standard alloys may be used:
- | | |
|---------|------|
| BS 1470 | 6082 |
| BS 1474 | 6082 |
- 7.4 Materials for attachments (including non-aluminium alloy)**

The Independent Inspecting Authority shall be satisfied that the material used in attachments is suitable in all respects including weldability where relevant.

Table 2 — Cast analysis

Element	Chemical composition		
	Type A (6082) ^a	Type B	Type C (6063 ^a complies)
Silicon %	0.7 to 1.3	1.2 to 1.6	0.2 to 0.7
Iron %	0.50 max.	0.5 max.	0.5 max.
Copper %	0.10 max.	0.1 max.	0.1 max.
Manganese %	0.40 to 1.0	0.8 to 1.0	0.3 max.
Magnesium %	0.6 to 1.2	1.0 to 1.4	0.4 to 0.9
Chromium %	0.25 max.	0.1 max.	0.1 max.
Zinc %	0.20 max.	0.2 max.	0.2 max.
Titanium %	0.10 max.	0.2 max.	0.2 max.
Others %	0.05 each	total 0.15	
Aluminium	Remainder	Remainder	Remainder
NOTE The rounding off rule given in BS 1957 applies to the limits given in Table 2.			
^a See clause 7.			

Table 3 — Mechanical properties

Mechanical properties	Type A		Type B	Type C
	TF	Alternative		
Tensile strength (N/mm ²)	295 min. ^a	275 min. ^a	275 min.	To be agreed with purchaser
0.2 % proof stress (N/mm ²)	255 min. ^a	195 min. ^a	195 min.	
Elongation % $L_0 = 50 \text{ mm}$	8 min.	—	—	
$L_0 = 5.65 \sqrt{S_0}$	—	14 min.	14 min.	
Bend test former radius (parent metal)	$3t_a$	$3t_a$	$3t_a$	
NOTE t_a is the actual thickness of the specimen.				
^a The manufacturer is to specify the selected value.				

Section 3. Design

8 Service conditions for design

8.1 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 4, the values of which vary with the type of gas contained.

Table 4 — Reference temperatures for developed pressure for conveyance in the United Kingdom 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.	

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 filled pressure at 15 °C for permanent gases.

NOTE The necessary data on the relationship between filled pressure or filling ratio and developed pressure at the reference temperatures are given in BS 5355.

The reference temperature for filling ratios of low pressure liquefiable gases in uninsulated containers shall be 45 °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 nominated gas content at 15 °C and 1 013 mbar.

The charged pressure shall 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 being conveyed in insulated containers the reference temperatures quoted in Table 4 shall not apply. In such cases the operational criteria for design shall be sought from the Independent Inspecting Authority.

NOTE The temperature which can be reached by the contents of an insulated container, 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 with halons and dry nitrogen the developed pressure requirements shall conform to the appropriate Part of BS 5306.

9 Classification of containers

9.1 General

Containers shall be constructed to one of the classes in 9.2, 9.3 or 9.4 depending on the intended application.

Construction criteria and other factors for each class shall be in accordance with Table 5.

9.2 Class I

Containers shall be constructed to class I if either of the following criteria apply:

- a) they are to be used to contain permanent or high pressure liquefiable gas or gas mixture (see Table 1);
- b) they are to be used for the transport of a toxic gas (see Table 1).

9.3 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 mechanized MIG or TIG welding process which has been shown to produce welds free from unacceptable defects.

Containers shall be constructed to class IA if they are to be used for the transport of the gases italicized in Table 1 (i.e. those gases which are of moderate toxicity or which give a sensory warning of a slight escape) subject to the Health and Safety Executive indicating that they have no objection to the proposal.

NOTE 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.

9.4 Class II

9.4.1 General. Containers for which construction to classes I, or IA, is not prescribed by 9.2 or 9.3 may be constructed to class IIA, IIB or IIC.

9.4.2 Class IIA. Containers shall only be constructed to class IIA if they do not possess a longitudinal seam, have outwardly dished ends and the distance (in 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 (in mm) and t_e is the actual thickness of dished end (in mm).

9.4.3 Class IIB. Containers for which construction to classes I or IA is not prescribed by 9.2 or 9.3 and which do not comply with the requirements of 9.4.2 or 9.4.4 shall be constructed to class IIB.

9.4.4 Class IIC. Containers shall only be constructed to class IIC where there is only a bung/boss seam not occurring in the cylindrical part of the container and where there is no longitudinal seam [see Figure 3(c)].

10 Design of container shell

10.1 Nomenclature for the cylindrical part of the shell

- t is the minimum thickness of the cylindrical wall (in mm), to resist internal pressure and external forces due to normal 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) and calculated in accordance with Table 6;
- P_2 is the test pressure (in bar) applicable to design governed by equations (3) and (6);
- 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 container (in mm);
- D_i is the internal diameter of container (in mm);
- f_e is the maximum permissible equivalent stress (in N/mm^2) at test pressure ($= 0.75 \times$ minimum specified 0.2 % proof stress Y (in 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 (in N/mm^2) of the material of construction;
- Y is the minimum specified 0.2 % proof stress (in N/mm^2) of the material of construction.

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

10.2 Permissible pressure

10.2.1 Permanent gas. The maximum pressure attainable in service shall not exceed the ratio of the minimum specified tensile strength to the minimum specified yield stress of the material of construction times 0.63 of the test pressure.

10.2.2 Liquefiable gas. The maximum pressure attainable in service is dependent upon the type of container used. It shall not exceed the ratio of the minimum specified tensile strength to the minimum specified yield stress of the material of construction times:

- 0.63 of the test pressure for an insulated container; or
- 0.7 of the test pressure for an uninsulated container.

Carbon dioxide containers shall be designed for a test pressure of not less than 200 bar.

10.3 Thickness of cylindrical wall

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

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

except that the thickness of the cylindrical wall 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 6.

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):

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

Table 5 — Classification and construction criteria

Classification by content		Classification of container (see note 4)				
		I	IA	IIA	IIB	IIC
Toxic gases (see 9.2)		×				
Toxic gas: moderate toxicity (see 9.3)			×	(see 9.3)		
Permanent and liquefiable gases having a developed pressure greater than 75 bar at 55 °C, including mixtures (see 9.2)		×				
Permanent and liquefiable gases having a developed pressure between 75 bar and 25 bar at 55 °C, including mixtures (see 9.3) (Non toxic, non flammable)			×			
Gases having a developed pressure lower than 25 bar at 55 °C [see 9.4 (Non toxic)]				×	×	×
					(see 9.4)	
Construction criteria						
Radiographic examination of welds at manufacture	Full	×				
	Sample		×			
	None			×	×	×
				(see note 2)		
Radiographic examination of weld repairs (see note 1)	Full	×	×			
	None			×	×	×
				(see note 3)		
Other factors						
Stress reduction factor		0.95	0.90	0.85	0.80	0.80
Batch number		202	202	402	402	402
Mechanical tests per batch		1	1	1	1	1
NOTE 1 All repairs to be approved by an Independent Inspection Authority.						
NOTE 2 Sample radiography is required for weld thicknesses 6 mm or above, otherwise none.						
NOTE 3 All repairs of weld thicknesses 6 mm or above are to be radiographed.						
NOTE 4 Classifications shown are minimum. Gases can be conveyed in containers of higher class than specified.						

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

$$t = 2.48 \sqrt{\left(\frac{D_i}{T}\right)} \quad (5)$$

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):

$$P_2 = \frac{7f_e}{1 + 0.12\sqrt{(D_i T)}} \quad (6)$$

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

Gas classification	Relationship between P_1 and p
Permanent gases in uninsulated containers, and liquefiable gases in insulated containers	$P_1 = \frac{p}{0.9} \times \frac{Y}{0.7T}$ $= p \times \frac{Y}{0.63T}$
Low pressure and high pressure liquefiable gases in uninsulated containers	$P_1 = p \times \frac{Y}{0.7T}$