CODE OF PRACTICE 29

The Design and Operation of Cylinder and Tube Trailers (Battery Vehicles) and Multiple-Element Gas Containers for the Safe Transport of Compressed Gases by Road

Revision 2: 2013

British Compressed Gases Association

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BRITISH COMPRESSED GASES ASSOCIATION
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PREFACE

The British Compressed Gases Association (BCGA) was established in l971, formed out of the British Acetylene Association, which existed since l901. BCGA members include gas producers, suppliers of gas handling equipment and users operating in the compressed gas field.

The main objectives of the Association are to further technology, to enhance safe practice, and to prioritise environmental protection in the supply and use of industrial gases, and we produce a host of publications to this end. BCGA also provides advice and makes representations on behalf of its Members to regulatory bodies, including the UK Government.

Policy is determined by a Council elected from Member Companies, with detailed technical studies being undertaken by a Technical Committee and its specialist Sub-Committees appointed for this purpose.

BCGA makes strenuous efforts to ensure the accuracy and current relevance of its publications, which are intended for use by technically competent persons. However this does not remove the need for technical and managerial judgement in practical situations. Nor do they confer any immunity or exemption from relevant legal requirements, including by-laws.

For the assistance of users, references are given, either in the text or Appendices, to publications such as British, European and International Standards and Codes of Practice, and current legislation that may be applicable but no representation or warranty can be given that these references are complete or current.

BCGA publications are reviewed, and revised if necessary, at five-yearly intervals, or sooner where the need is recognised. Readers are advised to check the Association's website to ensure that the copy in their possession is the current version.

This document has been prepared by BCGA Technical Sub-Committee 4. This document replaces BCGA CP 29, Revision 1: 2006. It was approved for publication at BCGA Technical Committee 147. This document was first published on 25/10/2013. For comments on this document contact the Association via the website www.bcga.co.uk.

CONTENTS

* Throughout this publication the numbers in brackets refer to references in Section 8. Documents referenced are the edition current at the time of publication, unless otherwise stated.

TERMINOLOGY AND DEFINITIONS

Battery vehicle	An assembly of cylinders, tubes or bundles connected to a manifold and securely mounted onto a vehicle chassis such that the assembly is filled, transported and emptied as a single unit.
Bundle or Manifold Cylinder Pallet (MCP)	Portable assembly, which is designed for being routinely lifted, and which comprises of a frame and two or more cylinders each of capacity up to 150 litres connected to a manifold by cylinder valves or fittings such that the cylinders are filled, transported and emptied without disassembly. The term "cylinder bundle" is synonymous with the term "bundle".
Carrier	The enterprise which carries out the transport operation with or without a transport contract.
Compressed gas	A gas with a critical temperature below or equal to minus 50 °C.
Cylinder	Pressure containing receptacle. These are normally found in two categories: a) of a capacity not exceeding 150 litres. b) of a capacity exceeding 150 litres up to a maximum of 3000 litres; commonly known as tubes. NOTE: When the word cylinder is used alone in this document, it means cylinder, tube or bundle.
Cylinder trailer	A cylinder trailer is a type of battery vehicle consisting of a semi-trailer of an articulated vehicle or a draw bar trailer on which gas cylinders in packs or bundles are permanently attached to the frame of the trailer.
Cylinder vehicle	A type of battery vehicle consisting of, a motor vehicle (motorised chassis frame) on which gas cylinders in packs or bundles are permanently attached.
Design pressure	Value of the pressure that is used to perform stress calculations of gas retaining components other than cylinders within the battery vehicle.
Element	Individual items, which are typically combined, to construct a larger assembly. This can include, but is not restricted to, cylinders, tubes, and bundles of cylinders.
Final outlet	An assembly including an isolation valve fitted at the termination of the manifold pipework for connection of the user equipment.
Manifold	A pipework system connecting two or more cylinders or two or more packs to a common final outlet.
May	Indicates an option available to the user of this Code of Practice.

Motor vehicle	Motorised chassis frame fitted with a device for attaching trailers and/or framework for the securing of packs or containers.
Multiple-Element Gas Container (MEGC)	A unit containing cylinders or tubes or bundles of cylinders which are linked to each other by a manifold and mounted on a frame with lifting and tie-down attachments sufficiently strong for lifting and road transport when full.
Packs	Assemblies of cylinders interconnected by manifolds, firmly held together by metal fittings, and permanently fixed to a transport unit. Each pack is manifolded to a common final outlet.
Pigtail	A connection between cylinder and manifold. It may be manufactured from coiled metal tube to give a degree of flexibility.
Shall	Indicates a mandatory requirement for compliance with this Code of Practice.
Should	Indicates a preferred requirement but is not mandatory for compliance with this Code of Practice.
Tank codes for ADR tanks	The alphanumeric code which appears in Column 12 of the Dangerous Goods List of Chapter 3.2 of ADR describes the tank type in accordance with [4.3.3.1.1]. This tank type corresponds to the least stringent tank provisions that are acceptable for the carriage of the relevant substance in ADR tanks. The codes describing other permitted tank types are to be found in [4.3.3.1.2].
Trailer	Means 'chassis frame' on which are attached mounting points to secure packs or containers, and which are designed to be towed behind a motor vehicle.
Transport unit	The term transport unit means a motor vehicle without an attached trailer, or a combination consisting of a motor vehicle and an attached trailer.
Working pressure	Settled pressure at a uniform temperature of 288 K (15 °C) for a full battery vehicle.

CODE OF PRACTICE 29

The Design and Operation of Cylinder and Tube Trailers (Battery Vehicles) and Multiple-Element Gas Containers for the Safe Transport of Compressed Gases by Road

1. INTRODUCTION

This Code of Practice provides practical guidance on the design, construction, examination testing and certification, and the filling and discharging of cylinder vehicle / trailers used for the domestic and international conveyance of compressed gases. Cylinder vehicle / trailers come within the general requirements of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (4), this implements the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) (9), which provides a framework for dangerous goods to be carried internationally in road vehicles subject to compliance with standards for the packaging and labelling of the dangerous goods, and appropriate construction and operating standards for the vehicles and crew. National regulations can, however, result in some variations to the final system. Within these regulations gases are classified as Class 2 dangerous goods.

2. SCOPE

The gases usually conveyed are oxygen, hydrogen, helium, carbon monoxide, methane and nitrogen. This list is not exhaustive and other compressed gases may also be carried within this Code of Practice. This code may also be used as a basis for battery vehicles and Multiple-Element Gas Containers (MEGC) intended for liquefied gases and dissolved acetylene, provided the additional requirements specified in ADR (9) and BS EN 13807 (21), *Transportable gas cylinders. Battery Vehicles. Design, manufacture, identification and testing*, are also complied with.

NOTES:

1. Numbers in square brackets, e.g. [6.8.2.1] refer to sections of ADR (9). ADR (9) is revised biannually and these references should be checked against the extant version for any amendment.

2. The gases may be non-flammable, non-toxic, flammable, or toxic with an LC_{50} greater than 200 ml/m^3. Reference should be made to ADR (9) [2.2.2.1] for the classification of non-flammable, non-toxic, flammable, and toxic gases.

3. This Code of Practice does not cover bundle design.

4. This code does not cover the requirements for Construction and Use of Vehicles legislation, which must also be observed as appropriate.

Figures 1 to 6 provide diagramatic examples of the vehicles covered by this code of practice.

EXAMPLES OF VEHICLES COVERED BY THIS CODE OF PRACTICE

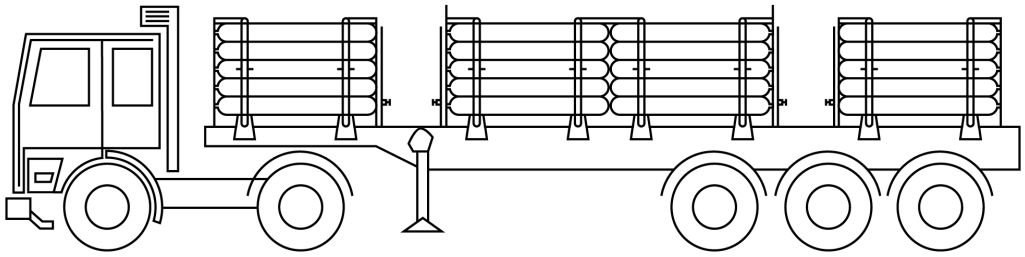

Figure 1: Cylinder trailer

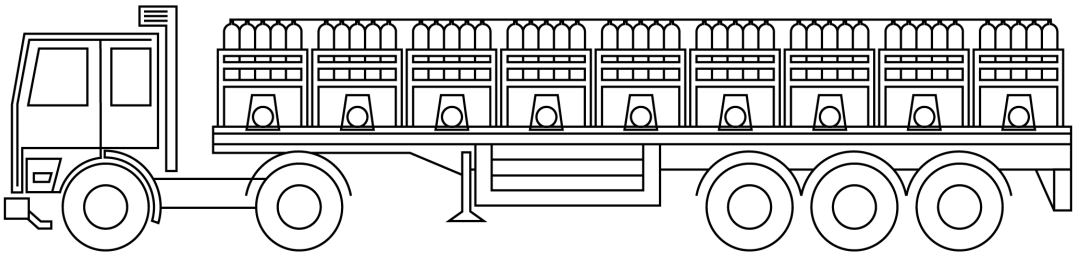

Figure 2: Cylinder trailer

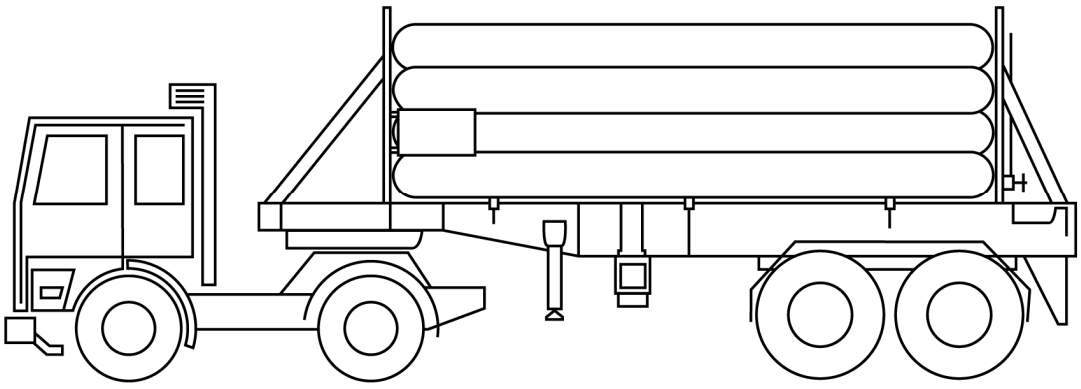

Figure 3: Cylinder trailer (tube trailer)

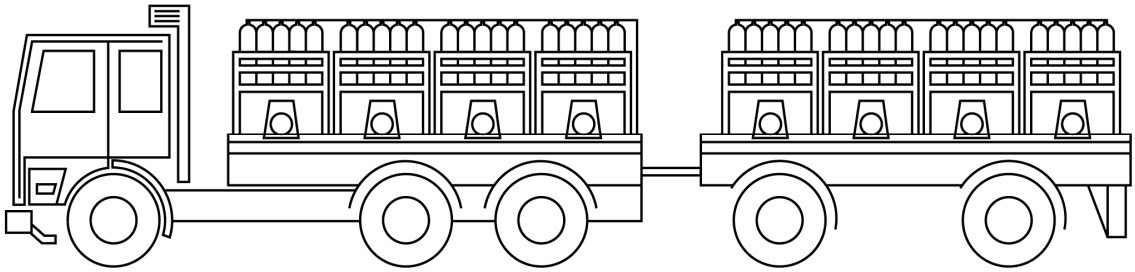

Figure 4: Cylinder vehicle and draw-bar trailer

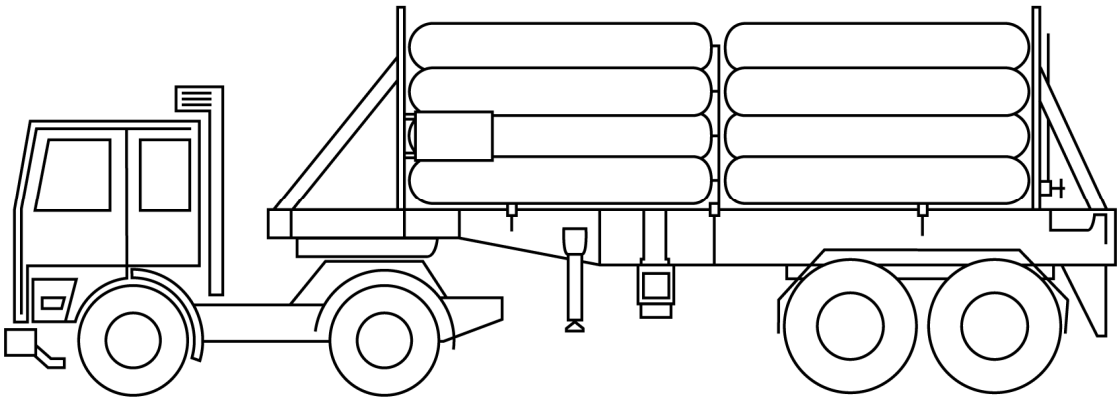

Figure 5: Cylinder trailer (tube trailer)

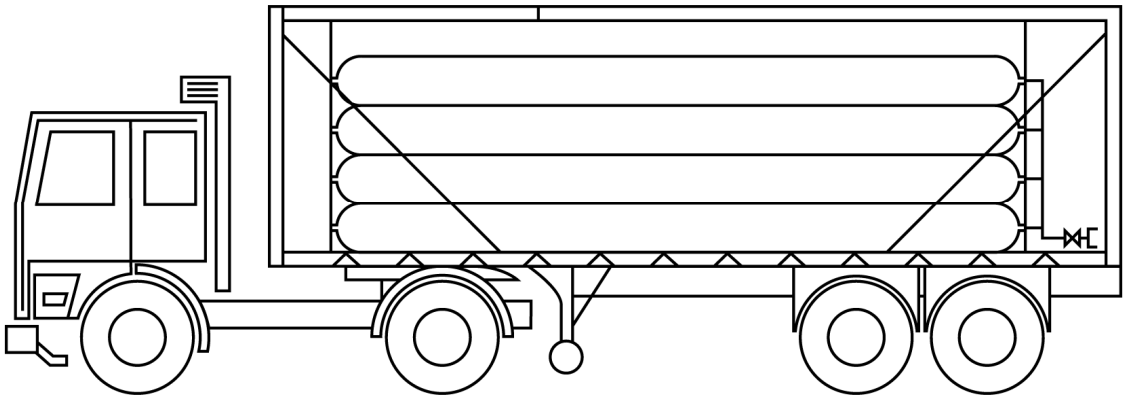

Figure 6: Cylinder vehicle incorporating multi-element gas container

3. CYLINDER TRAILER OR VEHICLE

The European Industrial Gases Association (EIGA) document 52 (23), *Load securing of Class 2 receptacles*, provides information concerning the necessary requirements for transporting individual gas cylinders, bundles, pallets of gas cylinders and cryogenic receptacles.

European Community Whole Vehicle Type Approval (ECWVTA). All new vehicles and trailers built after 29th April 2103 shall comply with European directive 2007/46/EC (7), this establishes a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.

3.1 Stability

Refer to ADR (9) [9.7.5.1]. The overall width of the ground-level bearing surface (distance between the outer points of contact with the ground of the right-hand tyre and the left-hand tyre of the same axle) shall be at least equal to 90 % of the height of the centre of gravity of the laden tank-vehicle. In an articulated vehicle the mass on the axles of the load-carrying unit of the laden semi-trailer shall not exceed 60 % of the nominal total laden mass of the complete articulated vehicle.

NOTE: As the designer may be unaware of the truck on which an MEGC will be in use, or will not be able to guarantee the use of a particular truck over the lifetime of a MEGC, it will not be possible to guarantee the requirement about the centre of gravity.

Cylinder attachments

Refer to ADR (9) [6.8.2.1.2], [6.8.3.1.5]. Cylinders, their service equipment and their fastenings shall be capable of withstanding without loss of contents, under the maximum permissible load, the forces defined as follows:

- In the direction of travel: twice the total mass;
- At right angles to the direction of travel: the total mass;
- Vertically upwards: the total mass;
- Vertically downwards: twice the total mass.

Under each of the above forces the stress at the most severely stressed point of the element and its fastenings shall not exceed the value defined in ADR (9) [6.2.5.3.] for cylinders, tubes, pressure drums and bundles of cylinders.

NOTES:

1. Calculated independently of each other.
2. Chassis loadings shall in other respects conform to normal principles of general haulage.

3.2 Impact protection

Refer to ADR (9) [9.7.6], [6.8.3.2.18], [6.8.3.2.19]. An arrangement shall be fitted at the rear of the vehicle to provide adequate protection to the rear pipework and fittings

to prevent accidental leakage of product in the event of a rear impact during transport. The arrangement shall meet at least the impact requirements for the rear under-run protective device required by EU Directive 79/490/EEC (5) as amended by Commission Directive 81/333/EEC (6). The width of this arrangement shall not be less than that of the rear under-run protective device. There shall be a clearance of at least 100 mm between the arrangement and the rearmost point of the piping, fittings and valves in contact with the gases being carried.

Manifolds shall be designed such that they are protected from impact in the event of a battery vehicle rolling onto its side or upside down.

3.3 Fire-fighting appliances

These shall comply with the requirements of ADR (9) [8.1.4].

NOTE: ADR (9), [8.3.2], requires that members of the vehicle crew shall know how to use the fire-fighting appliances.

3.4 Electrical system

Refer to ADR (9) [9.2.2]. For flammable gases the electrical system should be designed, installed and adequately protected to minimise mechanical damage and risk of electrical fires. In particular, the system should conform to the following requirements:

(i) The nominal circuit voltage of any circuit on the vehicle should not exceed 24 volts;

(ii) All cables should be located and secured on the vehicle so that they are protected against vibration, mechanical damage and heat;

(iii) All control switches, where fitted, should be in the feed-side of the circuit;

(iv) Where practical, circuits shall be protected by fuses or automatic circuit breakers. Unprotected circuits shall be as short as possible.

(v) The size of conductors shall be large enough to avoid overheating. Conductors shall be adequately insulated.

3.5 Braking

The braking system and attachments between tractor and trailer shall be in accordance with current EU directives. Refer to ADR (9) [9.2.3] for details.

3.6 Static electricity

Refer to ADR (9) [7.5.10], [8.5 S2 (3)]. In the case of flammable gases, electrical continuity should be maintained throughout the pipework system and between the pipework, the cylinders and their supports. An earthing connection shall be provided for use during loading and discharging and its position should be clearly indicated and be readily accessible. Flexible hoses should be of the electrically continuous type with a resistance not exceeding 10 ohms.

3.7 Identification plates

Refer to ADR (9) [6.8.3.5.10 to 6.8.3.5.12]. Every battery-vehicle or MEGC shall be fitted with a corrosion-resistant metal plate permanently attached in a place readily accessible for inspection. The following particulars, at least, shall be marked on the plate by stamping or by any other similar method:

- Approval number;
- Manufacturer's name or mark;
- Manufacturer's serial number;
- Year of manufacture;
- Test pressure (gauge pressure)
- Design temperature (only if above +50 °C or below -20 °C);
- Date (month and year) of initial test and most recent periodic test in accordance with ADR (9) [6.8.3.4.10] to [6.8.3.4.13];
- Pi (π) mark where relevant (refer to Section 4.4);

NOTE: The Pi (π) mark has to conform with European Directive 2010/35/EU (8) on transportable pressure equipment.

- Stamp of the expert who carried out the tests (and / or the notified body number in the case of application of the Pi (π) mark).

Optional markings:

- Date of the next periodic test of the cylinders;
- Reference number which identifies the serial numbers of the cylinders fitted.

Additional marking.

The following particulars shall be inscribed on the battery-vehicle or MEGC itself or on a plate:

- Names of owner or of operator;
- Number of elements;
- Total capacity of the elements;

and for battery-vehicles filled by mass:

- Unladen mass;
- Maximum permissible mass;
- The tank code including the test pressure;

NOTE: The code shall describe the actual construction, not the code of the intended substance(s) which may be lower in the hierarchy.

and in the case of MEGCs:

- The proper shipping names of the gas(es), including technical names in the case of an N.O.S. (Not Otherwise Specified) entry.
- The tare if the MEGC is filled by mass.

The frame of a battery-vehicle or MEGC shall bear near the filling point a plate specifying:

- The maximum filling pressure at 15 °C allowed for elements intended for compressed gases;
- The proper shipping names of the gas(es), including technical names in the case of an N.O.S. entry;

and in the case of liquefied gases:

- The permissible maximum load per element.

The units of measurements shall be added after all numerical values.

3.8 Other information

The following information shall be clearly identified on the outside of the vehicle:

(i) A unique identification number, which is permanently attached;

(ii) An instruction to close cylinder valves in transit when this is necessary.

4. SUBSTANCE RELATED PROVISIONS

4.1 Design – General

NOTE: Section 4 should be read in conjunction with ADR (9) [6.8.3].

A trailer shall be designed such that it is safe to build, test, transport and operate.

All components shall be designed to operate in the temperature range of –20 °C to +65 °C.

4.2 Compatibility

All equipment in contact with the gas shall be selected so as to be unaffected by the gas or its trace contaminants in concentrations which the gas supplier specifies as liable to be present. Refer to BS EN ISO 11114 (18), G*as cylinders. Compatibility of cylinder and valve materials with gas contents*.

4.3 Tank code – Specification of pressure containment characteristics

The characteristics of the pressure envelope (Pressure Relief Devices, openings) for each substance are defined by the tank coding (refer to ADR (9) [4.3.3.1.1] for an explanation of tank coding and ADR (9), Chapter 3.2, Table A, Column 12 for the code relevant to each substance). Designers must ensure that the pressure containment meets or exceeds the substance(s) tank code(s). ADR (9) [4.3.3.1.2] gives the permissible more stringent variations in the pressure containment characteristics. A typical example is C300BH.

4.4 Cylinders

Cylinders shall be designed and constructed in accordance with ADR (9), [Chapter 6.2].

Cylinders and valves manufactured after 1st July 2003 shall be Pi (π) marked and battery vehicles and MEGCs manufactured after 1st July 2005 may be Pi (π) marked if assembled from Pi (π) marked cylinders and valves. Pi (π) marking is mandatory in all cases of completely new build after 1st July 2007. Where, however, old cylinders (not Pi (π) marked) are built into a new frame the frame must comply with BS EN 13807 (21) but no Pi (π) mark will be applied, and the unit can only be used for domestic transport.

Cylinders already in service shall be accepted providing they still conform to the standards of the original build. For hydrogen service, particular attention shall be paid to ensuring that the cylinders are resistant to hydrogen embrittlement.

4.5 Cylinder supports

Cylinders should be secured in a manner that prevents both movement in relation to the trailer and the concentration of local stresses. In particular, the bottom cylinders of a stack, and cylinders to which clamping forces are applied, should not be subjected to point loads that result in concentrations of high local stress. Suitable means should be provided to distribute this loading.

The cylinders should have their weight supported directly from their bodies and not from separate collars or valve caps unless these are specifically designed for this purpose. The supports and holding down straps should be such as to minimise the risk of corrosion to the cylinders. Absorbent materials are not recommended unless they are treated to eliminate absorption. Examples of suitable materials are water resistant belting and rubber.

ADR (9) [9.7.3] requires that fastenings shall be designed to withstand static and dynamic stresses in normal conditions of carriage, and minimum stresses as defined in [6.8.2.1.2], [6.8.2.1.11] to [6.8.2.1.16] in the case of battery-vehicles.

4.6 Cylinder valves

Refer to ADR (9), [6.8.3.2.25], [6.8.3.2.26]. Each cylinder, including each individual cylinder of a bundle, intended for the carriage of toxic gases shall be capable of being isolated by a shut-off valve. In the case of cylinders carrying other gases a connector may be used. The valve or connector should have a neck with a taper thread conforming to BS EN ISO 11363 (19), *Gas cylinders. 17E and 25E taper threads for connection of valves to gas cylinders*, or an equivalent standard. Alternative connections of equivalent safety (e.g. parallel threads) may also be used.

Cylinder isolating valves are not required to be closed during transit.

Battery vehicles and MEGCs intended for the carriage of toxic gases shall not have safety valves, unless the safety valves are preceded by a bursting disc. In the later case, the arrangement of the bursting disc and safety valve shall be satisfactory to the competent authority.

4.7 Manifold and pack valves

Refer to ADR (9), [6.8.3.2.22], [6.8.3.2.28]. There should be at least two isolating valves between the gas at high pressure and the final outlet. The design of valves should be such that the failure of any internal component would not cause a projectile to be ejected.

An isolating shut-off valve shall be fitted where the trailer contains flammable gas to limit the volume covered by a single valve to 5000 litres water capacity. Where valves are not accessible from the ground a safe means of access should be built into the design. These requirements are not applicable to non-flammable, non-toxic gases.

4.8 Pipework

Refer to ADR (9), [6.8.3.2.20], [6.8.3.2.21]. The pipework of a trailer shall be suitable for the gas at the temperature and pressure for which the trailer is intended.

The design stress levels shall not exceed 1/5 x tensile strength or 2/3 x proof stress of the material, whichever is the lowest.

The design pressure shall be at least 1.1 x working pressure.

Pressure retaining components shall be designed for a proof test pressure which corresponds to a minimum 1.5 x working pressure.

Any part of the manifold shall not bear against other components in the bundle except at cylinder valve / fitting interfaces or at defined attachment points to the frame.

Where pipework is made of metal, the necessary flexibility should be achieved by the use of bends or pigtails. Flexible hoses or non-metallic pipework should only be used as part of the fixed pipework on the trailer after trials have proved their acceptability, and such hoses and pipework should be kept to a minimum.

All materials shall be suitable for service with the gas at the temperatures and pressures involved. Copper pipework and joints should be designed to BS 1306 (13), *Specification for copper and copper alloy pressure piping systems*, or an equivalent

acceptable standard taking into account the pressure test requirements of Section 7.2. Where appropriate, copper pipework should be annealed or stress-relieved. If materials other than copper or copper alloy are used, the design should be to an equivalent standard.

Cast-iron pipe and fittings shall not be used for hydrogen service. Consideration shall be given to the permeability of hydrogen and the risk of embrittlement of some ferrous materials when selecting equipment for hydrogen service.

Permanent joints should be hard soldered, brazed or welded. Connections may be flanged, screwed union connections or compression fittings. Compression fittings should not be used except where items may need to be removed for maintenance, e.g. manifold valves. The initial assembly of compression fittings should be done at a bench using a purpose-made assembly jig. Each olive or ring should be checked for adequacy of engagement and alignment before final assembly. The size of compression fittings used for flammable or toxic gases should not exceed 25 mm nominal bore.

Unless pipework is mounted and so protected by the vehicle / trailer structure a means should be provided to protect the pipework from side impact and rollover.

When in transit, there shall be at least two closed valves between the gas in the cylinders and the final outlet. One of these should be a final valve adjacent to the final outlet. Where toxic gases are carried, means should be provided to prevent unauthorised operation of this valve. Additionally for toxic gases, a valve of such a design that it is normally closed and may be operated remotely shall be fitted upstream of the main outlet valve.

If the final outlet is capped or plugged during conveyance the design of the plug should be such that any build up of pressure can be released in a safe manner.

Before putting into service, pipework shall be pressure tested and be free of dirt and other contaminants.

The final outlet connection or the outlet connection from a bundle shall be designed so that incorrect connections to other gas products cannot be made.

4.9 Pressure gauge

Except as mentioned below, a pressure gauge conforming to the requirements of BS EN 837-1 (11), *Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing*, or equivalent should be installed in the pipework, visible from the location of the outlet, which measures the pressure in the manifold prior to the outlet. The dial of this gauge should not be less than 150 mm diameter, with the smallest division of the scale equivalent to 2.5 % of the filling pressure. An alternative means of pressure indication of equivalent readability may be used.

4.10 Labelling and colour coding

Refer to ADR (9), [6.8.3.5.13]

4.10.1 Labelling

The design may include components that protect the manifold and cylinder, which may cause an obstruction to the view of the shoulders of the cylinders. Therefore the requirements for labelling individual cylinders defined in BS EN ISO 7225 (16), *Gas cylinders. Precautionary labels*, do not apply. Individual cylinders are not required to have labels attached.

Additionally, markings on the individual cylinders may also be obscured, therefore certain information which requires to be checked at the time of filling shall be duplicated on the outside of the transport unit, refer to Section 3.7.

The labelling and placarding of transport units shall comply with ADR (9), [Chapter 5.3] for international journeys. For national carriage within the UK the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (4), Regulation 6 and Schedule 1, Part 1 apply. However, vehicles may also be used as static storage and in these cases labelling similar to that used for bundles could be used.

The minimum size of the side of the hazard warning diamond shall be 250 mm if not associated with the hazard warning panel or bundles.

In addition to the hazard warning panels, each transport unit should have, and be labelled with, a unique identification number. This should be indelibly marked in characters not less than 50 mm high, refer to Section 3.8 (i).

4.10.2 Colour coding

The use of the cylinder colours defined in BS EN 1089-3 (12), *Transportable gas cylinders. Gas cylinder identification (excluding LPG). Colour coding*, is not mandatory for cylinders assembled into a transport unit. Where colour coding is applied then it is recommended that it is in-line with BCGA Technical Information Sheet 6 (25), *Cylinder identification. Colour coding and labelling requirements*.

The colour of the transport unit chassis shall carry no significance with respect to the gas contained.

4.10.3 Cylinder neck rings

Cylinder neck rings placed under the cylinder valve providing all the statutory information required about the cylinder must be fitted if this information is not provided on the wall of the cylinder. Other neck rings providing a date that the cylinder is to be removed from service and tested need not be fitted.

5. OPERATIONAL PROVISIONS

5.1 Purging

Before filling for the first time with a flammable gas after assembly, repair or loss of pressure, such that there is insufficient residual pressure adequately to purge the filling connections, oxygen should be removed from all parts of a pressure system until the residual oxygen concentration is less than 1 % v/v. This may be achieved by alternately pressurising to 7 bar gauge with inert gas and venting off until the required oxygen concentration is reached. The number of times the system must be purged to enable an oxygen concentration of 1% v/v to be achieved, should be determined by initial trials which should include analytical measurement of the oxygen concentration. Alternatively, the system may be evacuated to 5 torr and the vacuum broken using dry inert gas or the product gas to leave a residual positive pressure. Unless the transport unit is to be filled immediately with product gas, a dry inert gas pressure of at least 2 bar should be maintained.

5.2 Working pressure

The value of the working pressure for the transport unit shall be indicated adjacent to the filling connection in contrasting, legible characters not less than 50 mm high. This pressure shall be no greater than the working pressure of the lowest rated cylinder.

5.3 Liaison between filler and operator

Formal systems shall be agreed between the operator and the filler to ensure that all operations are carried out correctly. In particular, if the operator requires a transport unit to be purged by the filler a suitable label should be attached to the connection point on the vehicle.

If individual cylinders or packs of cylinders are temporarily valved off (e.g. following a leak), these cylinders or packs should be so labelled and the labels should only be removed following repair procedures.

A similar procedure should be agreed when an operator requires a leak test to be made using the product gas.

5.4 Inspection prior to filling

Before filling a transport unit it shall be verified by visual examination that:

- The transport unit is permitted to be filled in the country of the filling station;
- The transport unit has an unexpired test date;
- The transport unit is suitable for the intended gas content and filling pressure or filling weight;
- The cylinder supports or bundle frames are free from damage which will affect their mechanical integrity;
- The restraining bars or straps to prevent the cylinders from rotating are secure and that cylinders have not rotated whilst in-service;

- The external cylinders are free of any signs of dents, cuts, gouges, fire damage or any other signs of damage. Rejection criteria shall be the appropriate standard for the periodic inspection and testing of the cylinder. Where any cylinder is damaged the transport unit shall be either dismantled and the cylinder inspected and revalidated, or the cylinder positively isolated and revalidated at a later date. In the case of fire damage all cylinders shall be inspected and any suspect cylinders shall be revalidated;

- The cylinder valves, where fitted and any isolating shut-off valves are all in the open position;

- A functional test is carried out on the main outlet valve and the remote control valve (if fitted) this shall include ensuring that the valve operates freely;

- The main outlet is free from contamination and is undamaged and has the correct thread for the gas to be filled;

- The transport unit is labelled in accordance with all applicable statutory requirements.

In addition, it shall be verified that the transport unit is free from any internal contamination that may affect the integrity of the pressure system by ensuring that the transport unit has a minimum residual pressure of 2 bar.

The requirements of Section 5.4 should be documented and signed off by the filler to enable a traceable record to be maintained by the operator.

5.5 Immobilisation and earthing

5.5.1 Immobilisation

A suitable device shall be engaged whereby the transport unit cannot be driven or moved when a loading or discharge hose is connected. EIGA Document 63 (24), *Prevention of tow-away accidents*, recommends practical methods of achieving this.

5.5.2 Earthing

In the case of flammable gases, an earthing connection must be made between the filling point and the transport unit before the filling process commences.
There shall be electrical continuity between the transport unit and the filling point.

5.6 Inspection during filling

During filling it shall be verified that no apparent leaks exist. Particular attention shall be paid with toxic and flammable gases.

5.7 Disconnection

Prior to disconnection, the hose assembly shall be vented and purged as appropriate for the product service in a manner that prevents the vented gas from causing any form of hazard.

5.8 Inspection after filling

Upon completion of the filling of the transport unit it shall be verified that:

- The transport unit has not been over-filled. For gases filled by pressure this will require correcting the pressure against temperature;
- The fill hose has been disconnected;
- The valves required to be closed for transport have been closed;
- The transport unit has been correctly labelled for the gas duty and any transport requirements;
- The main outlet valve is not leaking;
- That all immobilising equipment has been removed, connections plugged, where applicable and no loose equipment remains on the transport unit.

The requirements of Section 5.8 should be documented and signed off by the filler to enable a traceable record to be maintained by the operator.

5.9 Filling and discharging - general

Transport units should be immobilised as per Section 5.5.1 before any transfer operations are started, and should remain so while still connected to the static pipework. Smoking shall not be permitted during filling and discharging and the engine shall be shut off.

For flammable gases, the transfer operation shall start / finish with the connection / removal of the earthing connection. Sources of ignition, such as lighted cigarettes and naked lights, should not be permitted within 5 m of transfer operations involving flammable gases.

A formal assessment of the area as specified in the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) (3) shall be carried out and the area classified and a relevant 'Ex' sign displayed. Refer to Figure 7 for an example sign. Electrical equipment in the area adjacent to transfer operations should be of the appropriate hazard classification as defined in BS EN 60079-14 (22), *Explosive atmospheres. Electrical installations design, selection and erection*.

Figure 7:
Example 'EX' sign

Loading and unloading facilities should be sited in a well ventilated place, preferably in the open air.

During the first filling of a new or repaired transport unit a gas tightness test shall be carried out. This may be achieved by raising the pressure in stages and checking for leaks at each stage, the first stage being of the order of 35 bar gauge pressure (not applicable in the case of acetylene).

The cylinders shall be filled so that the settled pressure does not exceed the working pressure. When cylinders are filled, particularly at a high rate, the temperature and hence pressure of the gas will rise initially and subsequently falls as the transport unit comes to thermal equilibrium with the environment. This effect should be determined by experiment (it can vary according to rate of filling, size of cylinders and orifices) and recorded in an appropriate manner.

Toxic and flammable gas transport units should not be discharged completely, a residual pressure of not less than 2 bar gauge should be maintained either by a written procedure or mechanical device. If a transport unit does not have this residual pressure it should go through a purging procedure before being filled.

Except during filling and discharging, the two isolating valves referred to in Section 4.6 should always be kept closed.

5.10 Dangerous Goods Safety Advisor

Businesses that handle, process or transport dangerous goods on a regular basis shall appoint a Dangerous Goods Safety Adviser (DGSA) in order to comply with the Health and Safety at Work etc. Act (1). Refer to ADR (9), [1.8.3].

5.11 Driver training

Driver training shall comply with ADR (9), [Chapter 8.2]. All drivers of vehicles carrying dangerous goods (including those with a gross vehicle weight of 3.5 tonnes or less) must have completed an approved training course, passed an approved examination and been issued an ADR (9) [8.2.2.8] Training Certificate.

5.12 Documentation

ADR (9) [8.1.2] details the documents required to be carried on a vehicle.

5.12.1 Transport document.

When dangerous goods are transported, the consignment must be accompanied by a transport document, declaring the description and nature of the goods. Documentation shall be in accordance with ADR (9), [5.4.1].

5.12.2 Instructions in writing

Instructions in writing shall be carried in the vehicle crew's cab and shall be readily available as an aid during any accident or emergency that may occur or arise during carriage. The instructions in writing shall be in accordance with ADR (9), [5.4.3].

The instructions in writing are to be provided by the carrier to the vehicle crew in a language(s) that each member of the crew can understand before the commencement of the journey. The carrier shall ensure that each member of the

vehicle crew concerned understands and is capable of carrying out the instructions properly. Before the start of the journey, the members of the vehicle crew shall inform themselves of the dangerous goods loaded and consult the instructions in writing for details on actions to be taken in the event of an accident or emergency.

5.13 Special equipment

Refer to ADR (9), [8.1.5].

5.13.1 Wheel chocks

At least one wheel chock of a size suited to the maximum mass of the vehicle and to the diameter of the wheels shall be provided.

5.13.2 Hazard warning kit

Two self-standing warning signs. The vehicle shall carry an emergency kit consisting of two self-standing cones or triangles or flashing battery-operated amber lights to warn other road users of a vehicle breakdown.

5.13.3 Tool kit

The vehicle shall have the necessary equipment for the driver to take the first safety measures, as required by the instructions in writing and by his training.

5.13.4 Miscellaneous – for each vehicle crew member

(i) A torch, of a type that shall not exhibit any metal surface liable to produce sparks;

(ii) An escape mask when toxic gas is being transported;

(iii) High-visibility jacket or vest, to be worn at all times.

(iv) PPE as specified in the instructions in writing, refer to Section 5.12.2. This is to include protective gloves and eye protection.

6. CYLINDER VEHICLES INCORPORATING MULTI-ELEMENT GAS CONTAINERS

6.1 Design

Multi-Element Gas Containers (MEGC) consist of a framework containing cylinders, tubes or bundles manifolded together. Refer to Figure 6.

The motor vehicle or trailer used for the carriage of MEGC's shall meet the appropriate requirements of Section 3 as required by UK regulations, with the exception that the static electricity connection shall be fixed to the container frame.

The substance related provisions shall be in accordance with Section 4 with the following exception:

The framework of a MEGC shall comply with the requirements of BS ISO 1496, Part 3 (14), *Series 1 freight containers -- Specification and testing. Part 3: Tank containers for liquids, gases and pressurized dry bulk*, or shall be of adequate design to support the cylinders in transit and when being lifted on or off the vehicle. Where appropriate, the design shall comply with the Freight Containers (Safety Convention) Regulations (2). The framework shall be designed so that it can be secured to the vehicle in an adequate manner, e.g. by the use of twist locks on the vehicle.

6.2 Operation

Section 5 applies in full.

7. TESTING AND EXAMINATION

7.1 General

(a) Extract summarised from ADR (9) [6.8.2.3.1]:
The competent authority or a body designated by that authority shall issue in respect of each new battery-vehicle or MEGC a certificate attesting that the type, including fastenings, which it has inspected is suitable for the purpose for which it is intended and meets the construction requirements of ADR (9) [6.8.2.1], the equipment requirements of ADR (9) [6.8.2.2] and the special conditions for the classes of substances carried.

The certificate shall show:

- The results of the test;
- An approval number for the type. For MEGCs the approval number shall consist of the distinguishing sign of motor vehicles of the State in whose territory the approval was granted and a registration number;
- The tank code of the battery vehicle or MEGC in accordance with ADR (9) [4.3.3.1.1];
- The alphanumeric codes of special provisions of construction (TC), equipment (TE) and type approval (TA) requirements of ADR (9) [6.8.4] for those substances for the carriage of which the tank has been approved;

(b) Vehicle testing is considered in five distinct phases:

1) Design qualification testing of the mountings (refer to Section 7.1.1).

2) Design qualification testing of a manifold (refer to Section 7.1.2 (a)).

3) Production testing of a manifold (refer to Section 7.1.2 (b)).

4) Production testing of a fully assembled vehicle (refer to Section 7.2).

5) Re-qualification testing of vehicles (refer to Section 7.3).

7.1.1 Design qualification testing of mountings

Mounting drawings, specifications and calculations shall be checked by the Competent Authority or a body designated by that authority.

7.1.2 Manifolds

(a) Manifold drawings, specifications and calculations shall be checked by the Competent Authority or a body designated by that authority.

(b) The manifold shall be subjected to a pressure test programme which comprises of:

- Pneumatic leak test at the working pressure using dry oil-free air or nitrogen. This may be carried out with the gas that is intended to be used at first-filling, provided that the process has been assessed and adequate safety precautions taken.
- Proof test as described in Section 4.8.
- Repeat of pneumatic leak test as described in 7.1.2 (b).

7.2 Initial examination and testing

The cylinders shall be examined, tested and certified in accordance with the specification to which they are designed and manufactured. Refer to ADR (9), [6.8.3.4.10].

After fabrication the pipework shall be subjected to a gas or hydrostatic pressure test to a pressure not less than 1.5 times the working pressure of the cylinders. Gas testing shall only be carried out after the risks associated with the test have been fully assessed and a thorough inspection of the pipework has been made. Reference should be made to HSE Guidance Note GS 4 (10), *Safety in pressure testing*. After assembly on the vehicle the pipework system shall be examined and leak-tested to a pressure not less than 1.1 times the working pressure. These tests shall be certified by a body appointed by the competent authority and a test certificate issued. Any defective parts disclosed by these tests shall either be replaced or repaired and then re-tested before a certificate is issued.

7.3 Periodic examination and testing

Refer to ADR (9), [6.8.3.4.10], [6.8.3.4.12] and [6.8.3.4.13].

NOTE: Pi (π) marking of trailers.

As noted in Section 4.4 the issue of Pi (π) marking of the cylinders and frame depends on several factors:

- If the vehicle is to travel outside the UK then Pi (π) marking of both the cylinders and the frame is mandatory.

- If the vehicle is not to travel outside the UK then, provided that the cylinders are π-marked, and the frame complies with BS EN 13807 (21), a Pi (π) mark may be applied to the complete unit, but is not mandatory.

- If the vehicle is not to travel outside the UK and it is desired to use non Pi (π) marked cylinders, then they may be built into a frame (new frames built after 1st July 2007 must comply with BS EN 13807 (21)) which will not bear a Pi (π) mark.

- There is no time limit to the acceptability of non-Pi (π) marked units for UK transport.

The periodic inspection shall take place at not more than five-year intervals. It shall include a leak test at the maximum working pressure and an external examination of the structure, the elements and the service equipment without disassembling.

The cylinders and the piping shall be tested at the periodicity defined in ADR (9), [4.1.4.1], [Packing Instruction P200] and in accordance with the requirements of ADR (9), [6.2.1.6]. Cylinders shall be examined and tested as far as practicable in accordance with the procedures and requirements given in:

- BS EN 1802 (15), *Transportable gas cylinders. Periodic inspection and testing of seamless aluminium alloy gas cylinders*;

- BS EN 1968 (16), *Transportable gas cylinders. Periodic inspection and testing of seamless steel gas cylinders*;

- BS EN ISO 11623 (20), *Transportable gas cylinders. Periodic inspection and testing of composite gas cylinders*.

If any of the cylinders are replaced, the value of the permitted filling pressure (refer to Section 5.2) should be re-checked.

In some cases, cylinders tested on different dates and not subsequently filled may be assembled onto a vehicle, the cylinder assembly of which has a later test date. In such cases the cylinders may continue in service until the lapse of the interval specified in ADR (9), [4.1.4.1], [Packing Instruction P200] after the date of test for the vehicle provided that:

- The test date for the vehicle is not later than six months after the test date for any cylinder;

- The test date for the vehicle is not later than three months after the latest cylinder test date; and

- If the filler has any cause to doubt the fitness of any cylinder for further filling, the vehicle is immediately withdrawn from service for further

investigation and if necessary for the periodic inspection and testing of the cylinders.

Battery vehicles and MEGCs filled shortly before they are due for test and used for static storage may remain undischarged beyond their test date provided that the condition of each cylinder from a visual examination by the operator continues to be satisfactory.

All pipes (manifolds, cylinder valves and pigtails) shall be examined at the five-yearly test and tested at the intervals specified for the cylinders.

Vehicle mountings shall be visually inspected for evidence of any corrosion, deformation or fracture which may be structurally significant. If unsatisfactory, the mountings shall be repaired by a suitable procedure.

A certificate shall be issued to cover these examinations and tests. These certificates shall refer to the list of the substances permitted for carriage in the battery-vehicle or MEGC.

Pressure gauges should be checked every 12 months over their range against a test gauge. Records shall be maintained showing last and next test dates.

7.4 Exceptional Inspection

Refer to ADR (9), [6.8.3.4.14], [6.8.3.4.15] and [6.8.3.4.16]. An exceptional inspection and test is necessary when the battery-vehicle or MEGC shows evidence of damaged or corroded areas, or leakage, or any other conditions, that indicate a deficiency that could affect the integrity of the battery-vehicle or MEGC. The extent of the exceptional inspection and test and, if deemed necessary, the disassembling of elements shall depend on the amount of damage or deterioration of the battery-vehicle or MEGC. It shall include at least the examinations required under ADR (9), [6.8.3.4.15].

The examinations shall ensure that:

- The elements are inspected externally for pitting, corrosion, or abrasions, dents, distortions, defects in welds or any other conditions, including leakage, that might render the battery-vehicles or MEGCs unsafe for transport;

- The piping, valves, and gaskets are inspected for corroded areas, defects, and other conditions, including leakage, that might render battery-vehicles or MEGCs unsafe for filling, discharge or transport;

- Missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;

- All emergency devices and valves are free from corrosion, distortion and any damage or defect that could prevent their normal operation. Remote closure devices and self closing stop-valves shall be operated to demonstrate proper operation;

- Required markings on the battery-vehicles or MEGCs are legible and in accordance with the applicable requirements; and

- Any framework, supports and arrangements for lifting the battery-vehicles or MEGCs are in satisfactory condition.

A certificate shall be issued showing the result of these examinations and tests. These certificates shall refer to the list of the substances permitted for carriage in the battery-vehicle or MEGC.

7.5 Markings

Refer to ADR (9), [6.8.3.5]. Upon the completion of re-assembly of a vehicle, all of the data plates shall be re-stamped, where applicable, and new labels fitted as appropriate.

7.6 Documentation

Refer to ADR (9), [4.3.2.1.7], [6.8.3.4.16]. Records of the components used to produce a vehicle shall be maintained containing the following information:

- Unique serial number of the vehicle.

- The test pressure and working pressure of the vehicle.

- The gas service in which the vehicle was intended to be used.

- Cylinder serial numbers.

- Where, when and by whom the vehicle was assembled.

- Copy of the details as given on the vehicle plate.

- Confirmation of any analysis carried out e.g. moisture.

- Confirmation of any post assembly pressure tests.

- Confirmation that post assembly leak test(s) have been passed.

- The pressure at which the vehicle was released for service to the operation/customer.

- Test records of individual components or batches of components shall also be maintained such that they may be cross-referenced to individual vehicles.

- All records must be maintained for as long as the vehicle exists.

- Certificates issued showing the results of the tests, inspections and checks carried out in accordance with the re-qualification procedures of Section 7.3 and 7.4 shall be retained for the lifetime of the vehicle.

8. REFERENCES *

	Document Number	Title
1.		Health and Safety at Work etc. Act 1974
2.	SI 1984: No 1890	Freight Containers (Safety Convention) Regulations 1984
3.	SI 2002: No 2776	Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).
4.	SI 2009: No 1348	Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (as amended)
5.	EU Directive 79/490/EEC	European Commission Directive of 18th April 1979 relating to liquid fuel tanks and rear under-run protection of motor vehicles and their trailers.
6.	EU Directive 81/333/EEC	European Commission Directive of 13th April 1981 (amending Directive 79/490/EEC) relating to liquid fuel tanks and rear under-run protection of motor vehicles and their trailers.
7.	EU Directive 2007/46/EC	European Commission Directive 2007/46/EC (as amended) establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.
8.	EU Directive 2010/35/EU	European Commission Directive on transportable pressure equipment.
9.	ECE/TRANS/225	The European Agreement concerning the International Carriage of Dangerous Goods by Road. (ADR).
10.	HSE Guidance Note GS 4	Safety in pressure testing.
11.	BS EN 837 Part 1:	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
12.	BS EN 1089 Part 3:	Transportable gas cylinders. Gas cylinder identification (excluding LPG). Part 3: Colour coding
13.	BS 1306	Specification for copper and copper alloy pressure piping systems.
14.	BS ISO 1496 Part 3	Series 1 freight containers -- Specification and testing. Part 3: Tank containers for liquids, gases and pressurized dry bulk.

	Document Number	Title
15.	BS EN 1802	Transportable gas cylinders. Periodic inspection and testing of seamless aluminium alloy gas cylinders.
16.	BS EN 1968	Transportable gas cylinders. Periodic inspection and testing of seamless steel gas cylinders.
17.	BS EN ISO 7225	Gas cylinders. Precautionary labels.
18.	BS EN ISO 11114	Gas cylinders. Compatibility of cylinder and valve materials with gas contents.
	Part 1:	Part 1: Metallic materials.
	Part 2:	Part 2: Non-metallic materials
19.	BS EN ISO 11363	Gas cylinders. 17E and 25E taper threads for connection of valves to gas cylinders.
	Part 1:	Part 1: Specifications.
	Part 2:	Part 2: Inspection gauges
20.	BS EN ISO 11623	Transportable gas cylinders. Periodic inspection and testing of composite gas cylinders.
21.	BS EN 13807	Transportable gas cylinders. Battery Vehicles. Design, manufacture, identification and testing.
22.	BS EN 60079 Part 14	Explosive atmospheres. Electrical installations design, selection and erection.
23.	EIGA IGC Document 52	Load securing of Class 2 receptacles.
24.	EIGA IGC Document 63	Prevention of tow-away accidents.
25.	BCGA Technical Information Sheet 6	Cylinder identification. Colour coding and labelling requirements.

Further information can be obtained from:

UK Legislation	www.legislation.gov.uk
Health and Safety Executive	www.hse.gov.uk
British Standards Institute (BSI)	www.bsigroup.co.uk
European Industrial Gases Association (EIGA)	www.eiga.eu
British Compressed Gases Association (BCGA)	www.bcga.co.uk