

**Technical Code for refillable gas cartridges (pressure receptacles)
having a water capacity from 0.12 litre up to 1 litre for fire
extinguisher assemblies in accordance with ADR 2003 chapter 6.2,
clause 6.2.3**

CD01

Issue 2

July 2003

Contents

	Foreword.....	3
1	Scope.....	3
2	Normative references	3
3	Terms and definitions.....	3
4	Symbols	4
5	Materials.....	4
5.1	Material Compatibility	4
6	Design	5
6.1	Filling Ratio	5
6.2	Cylindrical Wall Thickness.....	5
6.3	Manufacturing Drawing.....	5
7	Construction and Workmanship.....	5
7.1	General.....	5
7.2	Wall Thickness.....	6
8	New Design Tests	6
8.1	General Requirements.....	6
8.1.1	Prototype Tests.....	6
8.1.2	Technical Specifications	6
8.1.3	List of Verification Tests	6
8.2	Description of Tests	7
8.2.1	Internal Volume	7
8.2.2	Pressure Test	7
8.2.3	Hydraulic Burst Test	7
8.2.4	Marking.....	8
8.2.5	Leakage Test	9
8.2.6	Pressure Cycling.....	9
8.2.7	Mechanical Tests.....	9
8.2.8	Forged End Inspection	10
8.2.9	Torque Test	10
9	Production Tests.....	10
9.1	General Requirements.....	10
9.2	Inspection and Testing During Production.....	10
9.2.1	Tests for Every Pressure Receptacle	10
9.2.2	Destructive Testing	10
9.3	Traceability.....	11
9.3.1	Pressure Retaining Parts.....	11
10	Records.....	11
10.1	Type Certification	11
10.2	Batch Certification	11
	Annex A (informative) Filling Ratio for CO ₂	12

Foreward

This technical code has been prepared in accordance with the requirements of ADR 2003, clause 6.2.3 in the absence of a design code listed in clause 6.2.2 relevant to refillable gas cartridges (pressure receptacles) for use in fire extinguishing assemblies.

1 Scope

This technical code specifies the requirements for the design, manufacture and testing for seamless and welded refillable steel transportable pressure receptacles from 0.12 litre up to 1.0 litre for use in fire extinguishing assemblies with a life limited to 10 years.

It is important to note that, due to a limited requirement for prototype and batch testing and the lower material properties as compared to the standard EN13293 listed in table 6.2.2 of ADR, this technical code must not be used for any other type of pressure receptacle. The limited testing reflects the use of these receptacles within a fire extinguisher, the limited number of fills to which they are subjected and a life limitation of 10 years.

2 Normative references

This technical code incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this technical code only when incorporated in it by amendment or revision.

EN 10204: 1991	Metallic Products – Types of inspection documents.
EN ISO 11114: 1997	Transportable Gas Cylinders – Compatibility of cylinder and valve materials with gas contents – Part 1 Metallic materials.
94/55/EC as amended	Council Directive 94/55/EC of 21 st November 1994 on the approximation of the laws of the member states with regard to the transport of dangerous goods by road.
BS6323: 1982	Specification for seamless and welded steel tubes for automobile, mechanical and general engineering purposes. Part 1 - General requirements Part 4 - Specific requirements for cold finished seamless steel tubes Part 5 - Specific requirements for electric resistance welded and induction welded steel tubes.
BS5355: 1976	Specification for filling ratios and developed pressures for liquefiable and permanent gases (inc amendment 3349 date January 1981).
EN10002:2001	Metallic materials – Tensile testing – Part 1 Method of test at ambient temperature.
GS4	Safety and Pressure Testing ; 1998 Third edition ISBN 07176 0811 5

3 Terms and definitions

3.1 Filling Ratio -The maximum allowable fill ratio measured in kg/l

3.2 Yield Stress – Value corresponding to the lower yield stress R_e or, for steels that do not exhibit defined yield, the 0.2% proof stress $R_{p0.2}$.

- 3.3 Batch – Quantity of cylinders plus cylinders for destructive testing of the same nominal diameter, thickness and design made from the same cast of steel.
- 3.4 Burst Pressure – Highest pressure reached in a cylinder during a burst test.
- 3.5 Test Pressure – Required pressure during the pressure test.
- 3.6 Working Pressure – Settled pressure at a uniform temperature of 288K (15° C) for full Pressure receptacle.
- 3.7 Material Certificate – material documentation to EN10204. 3.1.b or equivalent for cylinder material only.
- 3.8 Design Stress Factor (F) – Variable ratio of equivalent wall stress at test pressure (P_h) to guaranteed minimum yield stress (R_e)
- 3.9 Tmax - Maximum operating temperature declared by the manufacturer, in °C (minimum +65°C)
- 3.10 Family - Pressure receptacles having the same external diameter, wall thickness, material and manufacturing process.

4. Symbols

- a guaranteed minimum thickness, in millimetres of the cylindrical shell
- D outside diameter of the cylinder, in millimetres
- F design stress factor (see 3.8)
- P_s developed pressure at Tmax.
- P_h test pressure, in bar ¹⁾, above atmospheric pressure as given in P200 of ADR.
- R_e minimum guaranteed value of yield stress in megapascals (MPa)¹⁾
- R_g minimum guaranteed value of tensile strength in megapascals (MPa)¹⁾
- A percentage elongation

¹⁾ 1 bar = 10^5 Pa = 0.1 MPa

5 Materials

Non-metallic materials for pressure receptacles or attached parts subject to pressure are not permitted by this standard.

5.1 Material Compatibility

Materials of components that may be in contact with the contents and the contents of the fire extinguisher shall be compatible with both the contents and the material of other components as per EN ISO 11114-1.

6 Design

6.1 Filling ratio

There is a relationship between the filling ratio, the maximum allowable pressure and the maximum allowable temperature depending on the pressure-temperature curves of the contents e.g. filling ratios for CO₂ shall be either 0.66kg/L or 0.75kg/L, and the corresponding maximum allowable pressures at 65°C are 185.7 bar or 237.6 bar. Details shown in Annex A.

6.2 Cylindrical Wall Thickness

The guaranteed wall thickness (a) of the cylindrical shell shall be determined by experimental methods or calculated using the equation. The maximum developed stress value at test pressure must not exceed 0.77 of the yield stress R_e whether determined by calculation or experimental means.

$$a = \frac{D}{2} \left\{ 1 - \sqrt{\frac{10FR_e - \sqrt{3} \cdot p_k}{10 \cdot F \cdot R_e}} \right\}$$

where the value of $F \leq 0,77$.

with absolute minimum of $a = 1.5\text{mm}$.

6.3 Manufacturing Drawing

A fully dimensioned drawing shall be prepared which includes the specification of the material, the manufacturing process and details of any permanent fittings.

7 Construction and Workmanship

7.1 General

The pressure receptacles shall be produced by manufacturing from cold drawn seamless, electric resistance welded tube or induction welded tube. Metal shall not be added in the process of closure of the end.

7.1.1 Mechanical Properties

Material used for pressure receptacles shall at least comply with the values in BS6323 parts 1, 4 and 5 or equivalent, but must be at least to the values shown in table 1 (N/mm²).

Table 1

R _e minimum ²⁾	R _g minimum ²⁾	A minimum %
300	400	10

²⁾ 1 N/mm² = 1MPa

7.1.2 Chemical Properties

Material used for pressure receptacles shall at least comply with the values in table 2.

Table 2

C	Si	Mn	P	S
0.25	0.5	1.5	0.02	0.02

All values are maximum permitted percentage by ladle analysis.

The total of sulfur and phosphorus shall not exceed 0.03%.

7.2 Wall Thickness

The manufacturer shall ensure that sufficient evidence is available to demonstrate that the wall thickness at any point shall not be less than the minimum thickness specified.

8 New Design Tests

8.1 General Requirements

8.1.1 Prototype Tests

The following testing shall be carried out for each new design of cylinder under the supervision of a Notified Body.

A design shall be considered to be a new design when any of the following conditions apply.

- It is manufactured in a different factory, or
- It is manufactured by a different process, or
- It is manufactured from a different grade of steel, or
- The base profile has changed e.g., concave, convex or hemispherical, or if there is a change in the base thickness/cylinder diameter ratio, or
- The overall length has increased by more than 50%, or
- The nominal outside diameter has changed, or
- Change in design wall thickness, or
- The test pressure has increased, or
- The minimum guaranteed material mechanical properties have changed.

8.1.2 Technical Specifications

A technical specification of each new design of cylinder, including design drawing, design calculation (as applicable) and steel details shall be prepared by the manufacturer. Sufficient pressure receptacles shall be made available to complete all verification tests.

8.1.3 List of Verification Tests

The following tests shall be performed:

- Minimum volume test, see clause 8.2.1
- Pressure test, see clause 8.2.2
- Hydraulic burst test, see clause 8.2.3
- Marking requirements, see clause 8.2.4

- Leakage Test, see clause 8.2.5
- Pressure Cycling, see clause 8.2.6.
- Mechanical Test, see clause 8.2.7.
- Forged End Inspection, see clause 8.2.8.
- Torque Test, see clause 8.2.9.

8.2 Description of Tests

8.2.1 Internal Volume

Three sample pressure receptacles shall be subjected to a minimum internal volume test to clarify the fill ratio. The capacity shall not be less than the value declared on the design drawing.

8.2.2 Pressure Test

8.2.2.1 Test method

The test method used may be hydraulic or with the agreement of the Notified Body may be replaced by a test using a gas³⁾, where such an operation does not entail danger. The pressure receptacle with or without all fittings/coatings may be subjected to either test method.

The pressure gauge and/or filling scale shall be calibrated to a reference scale/gauge every batch and a record made. The reference scale or gauge shall be calibrated to a national reference at least every six months and a certificate kept until the time of the next calibration.

For test pressure methods based on pressure produced by temperature, the temperature must be checked against a calibrated thermometer and referenced for every batch and records kept. The thermometer shall be calibrated to a national reference at least every six months and a certificate kept until the time of the next calibration.

³⁾ Attention should be paid to HSE guidance note GS4 safety and pressure testing.

8.2.2.2 Test Requirements

The minimum test pressure shall comply with table A.1 in Annex A.

Each cartridge body (pressure receptacle) shall be subjected to the pressure test. This pressure shall be applied for a minimum of 30 seconds to ensure that it is leak tight. No visible deformation shall occur. For type testing a minimum of three pressure receptacles shall be subjected to the pressure test.

NOTE: A pressure receptacle that has successfully passed the pressure test may be utilised for one of the bursting tests. If this pressure receptacle fails the burst test it shall not be considered a failure but the full number of pressure receptacles required for the bursting test shall be applied.

8.2.3 Hydraulic Burst Test

8.2.3.1 Test method

The test method used must be hydraulic.

The minimum burst pressure shall not be less than 1.8 times the test pressure. The average rate of pressure increase shall not be > 50 bar/ second. It is important that no air is present during the test.

The adapter (as applicable) shall be fitted to the pressure receptacle during the test and shall remain leak tight up to the burst pressure.

The pressure gauge used to monitor the burst pressure shall be calibrated to a reference every batch and a record made. The reference gauge shall be calibrated to a national reference at least every six months and a certificate kept until the time of the next calibration.

8.2.3.2 Test Requirements

Any burst shall only occur in the cylindrical part of the pressure receptacle body as a single vertical ductile fracture without any branching.

The body shall not fragment, fail in the forged areas or connection between adapter and body.

A minimum of three pressure receptacles shall be subjected to the hydraulic burst test.

8.2.4 Marking

The marking shall be durable and waterproof and shall be affixed to the cylinder (permanent ink marking is acceptable). The marking may be applied to any external coating. The marking shall not become damaged during normal handling in manufacture and use and shall remain clearly legible. The minimum size shall be 2.5mm.

Where necessary the marked weights include all fittings and protective coatings.

The marking shall include at least the following:

- actual empty mass, in g or kg to 3 d.p
- theoretical full mass, in g or kg to 3 d.p.
- nature of contents and UN and number ; eg, CO₂ UN 1013
- mass of CO₂ or content, in g or kg to 3 d.p , and/or charging pressure of the compressed gas, in bar ;
- year and month of manufacture (as applicable) ⁴⁾
- mark or name of the manufacturer registered with the competent authority.
- Serial or batch number traceable to material cast/heat number.
- Thread code of pressure receptacle e.g. M16 x 1.5
- Mark of directive compliance (π). Minimum 5mm.
- Mark of Notified Body
- Water capacity in litres, followed by letter “L”
- Test pressure in bar, preceded by “PH” and followed by “BAR”.

- Characters identifying country of approval as indicated by the distinguishing signs of motor vehicles in international traffic e.g. GB for Great Britain.
- Reference to this technical code.

⁴⁾ If retest period is greater than or equal to ten years, then the month of manufacture is not required.

8.2.5 Leakage Test

Three sample pressure receptacles completed in accordance with the manufacturing drawing shall be submitted to a leakage test. Any suitable method may be used to determine an annual leakage rate, which shall not exceed 5%.

8.2.6 Pressure Cycling

One pressure receptacle per family to be subjected to a pressure cycling test without any fittings, to be carried out with a non corrosive liquid subjecting the pressure receptacle to successive reversals at an upper cyclic pressure which is equal to $0.9 \times P_h$. The lower cyclic pressure shall not exceed 30 bar. The pressure receptacle shall withstand 7000 cycles without failure. The frequency of reversals of pressure shall not exceed 0.25Hz (15 cycles per minute). The temperature measured on the outside surface of the cylinder shall not exceed 50°C during the test.

8.2.7 Mechanical Tests

8.2.7.1 Tensile Tests

Pressure receptacles subjected to heat treatment⁵⁾ after hot forming, three pressure receptacles shall be subjected to tensile testing to verify minimum mechanical properties as defined in table 1. For pressure receptacles with an internal volume <0.22 litre water capacity, a tensile test is not required; hydraulic burst testing (see clause 8.2.3) shall be used as an indication of ductility. When tensile specimens are required they shall be prepared and tested in accordance with EN10002-1. For location of test pieces see fig 1.

⁵⁾ The parallel area is not affected by the forming process and therefore no tensile test is required.

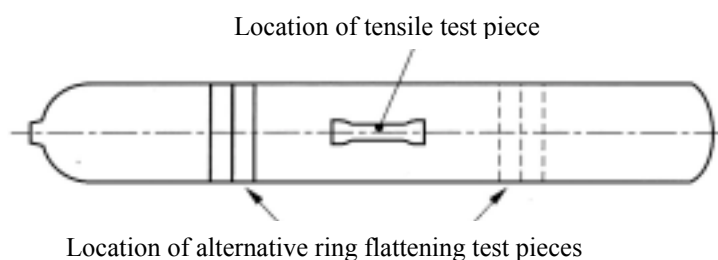
8.2.7.2 Flattening Tests

The flattening test shall be carried out on two rings 25mm wide taken from the cylindrical part of three pressure receptacles. Only edges of the rings may be machined. The rings shall be flattened between platens until the distance between the platens is five times wall thickness a . The flattened rings shall remain uncracked.

When carried out as a design test the flattening test shall be conducted at -50°C. When carried out as a batch test the flattening test shall be conducted at room temperature. For pressure receptacles which have been manufactured by controlled hot forming, i.e. no post forming, the rings shall be taken from the heat affected zones.

For location of test pieces see fig 1.

Fig 1



8.2.8 Forged End Inspection (Visual Inspection)

Forged ends of the pressure receptacle shall be sectioned and visually examined using a macro-section to ensure the minimum thickness is \geq to minimum guaranteed wall thickness (a) and that no defects are present.

8.2.9 Torque Test

Where applicable one example per family of pressure receptacle shall be assembled with the adapter/valve and torqued to destruction. The minimum fracture torque shall be ≥ 1.5 times maximum declared assembly torque.

9 Production Tests

9.1 General requirements

The manufacturer shall be technically competent and ensure that he has available the manufacturing means and processes suitable for fabricating the pressure receptacles in accordance with this technical code. The manufacturer shall operate an appropriate quality system approved by a Notified Body. BS EN ISO 9000:2000 may be used as a basis for this approval.

The manufacturer shall ensure that the materials and components used in the fabrication of the pressure receptacles are free from any defect likely to impair its safe use.

9.2 Inspection and testing, during production

9.2.1 Tests for Every Pressure Receptacle

All pressure receptacles shall be tested for resistance to test pressure and shall meet the requirements of 8.2.2 and 8.2.5. No visible deformation to the naked eye shall be evident.

9.2.2 Destructive Tests

One pressure receptacle per batch or 1000 receptacles, whichever is smaller, shall be subjected to the hydraulic burst test in clause 8.2.3, but with the exception that the adapter need not be assembled to the pressure receptacle.

9.2.2.1 Failure

If any pressure receptacle fails to meet the minimum requirements, further samples shall be taken in accordance with the Table 3 and 9.2.1 shall be repeated.

If one or more of the further samples fails to meet the minimum requirements, the whole batch shall be rejected.

Table 3

Batch sampling plan following failure	sample size
Batch size N	
$N \leq 1000$	13
$1001 < N \leq 2000$	20
$2001 < N \leq 4000$	30
Every additional 1000 or part of 1000	10

9.2.2.2 Flattening Test

Flattening test in accordance with 8.2.7.2 to be conducted on one sample per batch of receptacles, or maximum of 1000 receptacles, at ambient temperature. This may be performed on the whole pressure receptacle.

9.2.2.3 Forged End Inspection

One dome forged end to be inspected as per 8.2.8, excluding the macro section, to ensure minimum wall thickness.

9.3 Traceability

9.3.1 Pressure retaining parts

The identification and the control of the materials for all pressure retaining parts shall be such as to ensure that the materials used in manufacture meets the specification of the design.

This is realised by application of adequate procedures, internal to the manufacturer such as batch control.

10. Records

10.1 Type Certification

Type test certification and test reports shall be supplied by the Notified body for each family design. The Manufacturer shall keep the certificates for a minimum period of 10 years after the date of the last production to the certified type.

10.2 Batch Certification

Records shall be retained by the manufacturer for a minimum of ten years after the last manufacture of each design. The Manufacturer shall keep the certificates for a minimum period of 10 years after the date that the batch is placed on the market.

Annex A
(Informative)

Table A.1 - Filling ratio for CO₂

Filling Ratio kg/l	Tmax⁶⁾ °C	P_s⁶⁾ BAR at +65°C	P_h
0.66 ⁷⁾	65	185.7	190
0.75 ⁷⁾	65	237.6	250

⁶⁾ Tmax and P_s values at temperatures greater than 65°C can be found in BS5355.

⁷⁾ For calculations purposes filling ratios ≤ 0.66 shall be tested to 190 bar and filling ratios > 0.66 ≤ 0.75 shall be tested to 250 bar.

Permitted filling ratios and test pressures for other gases can be found in P200 of ADR.