Transportable gas cylinders —
Refillable welded steel cylinders containing adsorbent materials —
for sub-atmospheric gas storage and delivery
(Excluding acetylene)
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Foreword

This technical code has been prepared in accordance with the requirements of ADR 2005; clause 6.2.3 in the absence of a design code listed in clause 6.2.2 relevant to transportable refillable welded carbon steel cylinders (pressure receptacles) containing liquefied gases adsorbed onto solid microporous media. This technical code is required to allow the low pressure storage of certain gases (see Annex A) listed in P200 of the ADR.

Introduction

This technical code calls for the use of substances and procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage. It has been assumed in the drafting of this technical code that the execution of its provisions is entrusted to appropriately qualified and experienced people.

1 Scope

1.1 General description

This technical code specifies minimum requirements concerning material, design, construction and workmanship, type approval procedure and production testing of transportable refillable welded carbon steel cylinders of water capacity from 0,5 litre up to and including 12 litre exposed to ambient temperatures for the purpose of providing low pressure storage of certain liquefied gases with test pressure < 42 Bar.

The pressure shell of the receptacle is fabricated by drawing a cylindrical shape with base from plate and welding a machined plug (boss) into the open end of the shell to form the cylinder. This method of fabrication allows for insertion of the adsorbent material prior to sealing the cylinder. A small sample per batch is hydraulically tested with no adsorbent material present to demonstrate weld set-up integrity. The remaining cylinders of the batch are pneumatically tested at test pressure with adsorbent material sealed inside the cylinder.
1.2 Permitted gases
High pressure and low pressure liquefied gases as specified in Annex A.

1.3 Filling pressure
Less than 1 bar.g at 21ºC

1.4 Nominal water capacity
0.5 litres to 12 litres inclusive.

1.5 Cylinder bundles
Cylinder bundles are not authorized in this technical code.

1.6 Drawing
A fully dimensioned drawing shall be produced.

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 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. For undated references the latest edition of the publication referred to applies (including amendments).

EN 287-1, Approval testing of welders – Fusion welding – Part 1: Steels.


EN 473, Non-destructive testing – Qualification and certification of NDT personnel – General principles.

EN 962, Transportable gas cylinders – Valve protection caps and valve guards for industrial and medical gas cylinders – Design, construction and tests.

EN 970, Non-destructive examination of fusion welds – Visual examination.
EN 1435, *Non-destructive examination of welds – Radiographic examination of welded joints.*

EN 1964-1:1999, *Transportable gas cylinders – Specification for the design and construction of refillable transportable seamless steel gas cylinders of water capacities from 0.5 litre up to and including 150 litres – Part 1: Cylinders made of seamless steel with an $R_m$ value of less than 1100 MPa.*

EN 1968:2002, *Transportable gas cylinders – Periodic inspection and testing of seamless steel gas cylinders (excluding LPG).*


EN 10028-1, *Flat products made of steels for pressure purposes – Part 1: General requirements.*

EN 10028-3, *Flat products made of steels for pressure purposes – Part 3: Weldable fine grain steels, normalized.*

EN 10028-5, *Flat products made of steels for pressure purposes – Part 5: Weldable fine grain steels, thermomechanically rolled.*

EN 10052, *Vocabulary of heat treatment terms for ferrous products.*

EN 10083-1 + A1, *Quenched and tempered steels – Part 1: Technical delivery conditions for special steels (includes amendment A1:1996).*

EN 10120, *Steel sheet and strip for welded gas cylinders.*

EN 12517, *Non-destructive examination of welds – Radiographic examination of welded joints – Acceptance levels.*

EN 13322-1, *Transportable gas cylinders-Refillable welded steel gas cylinders-Design and construction- Part 1: Carbon steel*


CGA C-3—2003—*Standards for welding on thin-walled, steel cylinders—Sixth Edition.*


### 3 Terms, definitions and symbols

For the purposes of this Technical Code, the following terms, definitions and symbols apply.

#### 3.1 Terms and definitions

**3.1.1 yield stress**
value corresponding to the lower yield stress, $R_{eL}$, or 0.92 x the upper yield stress ($R_{eH}$) or for steels that do not exhibit a defined yield, the 0.2% proof stress ($R_{p0.2}$).

[EN 10002-1]

**3.1.2 stress relieving**
heat treatment given to the drawn pressure shell, the object of which is to reduce the residual stresses without altering the metallurgical structure of the steel, by heating to a uniform temperature below the lower critical point (AC$_1$, as defined in EN 10052) of the steel and cooling in a still atmosphere.

**3.1.3 final stress relief of finished cylinder**
final stress relief is given to the finished cylinder by heating to a minimum of 180°C for a minimum of 12 hours to insure impurities are removed from the adsorbent material contained within the interior of the cylinder.

**3.1.4 batch**
quantity of finished cylinders made consecutively during the same or consecutive days to the same design, size and material specifications and from the same material supplier for each pressure containing part on the same automatic welding machines and heat-treated under the same condition of temperature and duration.
NOTE  This definition allows different suppliers to be used for the different pressure
containing parts within a batch, e.g. one supplier for shells, another for plugs.

3.1.5  design stress factor (F)
ratio of equivalent wall stress at test pressure ($p_h$) to guaranteed minimum
yield stress ($R_e$).

3.1.6  inspection body
An independent third party appointed by the appropriate competent authority
to provide a verification service to manufacturers.

NOTE  This definition includes a Notified Body to the Transportable Pressure Equipment
Directive.

3.2 Symbols

$a$  Calculated minimum thickness, in millimetres, of the cylindrical shell

$a'$ Guaranteed minimum thickness, in millimetres, of the cylindrical shell
(including any corrosion allowance see 7.1)

$A$  Percentage elongation after fracture

$D$  Outside diameter, in millimetres, of the cylinder

$F$  Design stress factor (see 3.1.5)

$L$  Length, in millimetres, of the cylinder

$P_b$  Measured burst pressure, in bar$^1$, above atmospheric pressure, in the
burst test

$p_h$  Hydraulic test pressure, in bar, above atmospheric pressure

$R_e$  Yield stress, in megapascals, as defined in 3.1.1 and used for design
calculation

$R_{ea}$  Value of the actual yield stress in megapascals determined by the tensile
test

$R_{eH}$  Minimum value of the upper yield stress, in megapascals, guaranteed by
the cylinder manufacturer for the finished cylinder, in accordance with EN
10002-1

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$^1$ 1 bar = $10^5$ Pa = 0.1 MPa
$R_{\text{el}}$ Minimum value of the lower yield stress, in megapascals, guaranteed by the cylinder manufacturer for the finished cylinder, in accordance with EN 10002-1

$R_g$ Minimum value of tensile strength, in megapascals, guaranteed by the cylinder manufacturer for the finished cylinder

$R_m$ Actual value of tensile strength, in megapascals, determined by the tensile test (see 8.4)

$S_0$ Original cross-sectional area of tensile test piece, in square millimetres, according to EN 10002-1

$T$ Actual thickness of the test specimen, in millimetres

### 4 Materials and stress relieving

#### 4.1 General

#### 4.1.1
Materials supplied for shells shall conform to EN 10120, or EN 10028-1 and EN 10028-3, or EN 10028-1 and EN 10028-5.

#### 4.1.2
Materials supplied for machined plug shall conform to EN 10083-1 + A1.

#### 4.1.3
Grades of steel used for manufacture shall be compatible with the intended gas service (e.g. corrosive gases, embrittling gases) in accordance with EN ISO 11114-1.

**NOTE** Only steel pressure receptacles resistant to hydrogen embrittlement shall be used for gases assigned special packing provision of “d” as per Table 2 of P200 of ADR.

#### 4.1.4
The welding consumables shall be such that they are capable of giving consistent welds with minimum tensile strength at least equal to that specified for the parent material in the finished cylinder.

#### 4.1.5
The manufacturer shall obtain and provide certificates of the ladle analysis of the steel supplied for the construction of the pressure retaining parts of the cylinder.

#### 4.1.6
The manufacturer shall be able to guarantee traceability for each cylinder to the cast of steel it was manufactured from.
4.2 Stress relief of shell and plug

The drawn pressure shell and plug shall be delivered in the stress-relieved condition. The cylinder manufacturer shall certify that the drawn pressure shell and plug have been stress relieved after completion of all welding and shall certify the process of stress relief applied. Localised stress relief of the drawn pressure shell and plug is not permitted.

The actual temperature of stress relief to which a type of steel is subjected for a given tensile strength shall not deviate by more than 30°C from the temperature specified by the manufacturer for the cylinder type.

5 Design

5.1 General requirements

5.1.1 The calculation of the wall thickness of the pressure parts shall be related to the yield stress of the parent material. The requirement specified in 6.2.3.1 of ADR shall be met as follows: “At the test pressure, the stress in the metal at the most severely stressed point of the pressure receptacle shall not exceed 77% of the guaranteed minimum yield stress ($R_e$).”

**NOTE** For certain gases, additional corrosion allowance may be applicable.

5.1.2 For calculation purposes, the value of the yield stress $R_e$ is limited to a maximum of 0.85 $R_g$.

5.1.3 The internal pressure upon which the calculation of gas cylinders is based shall be the test pressure $p_h$.

5.1.4 A fully dimensioned drawing including the specification of the material shall be produced.

5.2 Calculation of cylindrical wall thickness

The wall thickness of the cylindrical shell shall be not less than that calculated using the formula:

$$t = \frac{p_h}{F \cdot \sqrt{R_g}}$$

where the value of F is the lesser of $\frac{1}{1.75}$ or 0.77.
— shall not exceed 0.85

The minimum wall thickness shall also satisfy the requirements of 5.4.

NOTE For certain gases, additional corrosion allowance may be applicable.

5.3 Design of shell ends

The thickness in the base of the cylinder shall be not less than that of the designed cylindrical section of the shell.

NOTE 1 End of cylinder must be designed to assure that at test pressure, the stress in the metal at the most severely stressed point of the cylinder end shall not exceed 77% of the guaranteed minimum yield strength ($R_e$).

NOTE 2 For certain gases, additional corrosion allowance may be applicable.

5.4 Minimum wall thickness

5.4.1 The minimum wall thickness of the cylindrical shell including the base, $a$, shall be not less than the value derived from the appropriate one of the following formulae:

for $D \leq 100$ mm, $a = 1.1$ mm;

for $100$ mm $< D \leq 150$ mm, $a = 1.1 + 0.008(D-100)$ mm;

for $D > 150$ mm, $a = $ ——— + 0.7 mm, with an absolute minimum of 1.5 mm.

5.4.2 The thickness of the end plug shall be at least twice that of the cylindrical shell.

NOTE 1 The end plug must be designed to assure that at test pressure, the stress in the metal at the most severely stressed point shall not exceed 77% of the guaranteed minimum yield strength ($R_e$).

NOTE 2 For certain gases, additional corrosion allowance may be applicable. This note should be for both the cylindrical section and plug.

5.4.3 No pressure relief devices shall be included in the design.
6 Construction and workmanship

6.1 General

The cylinder or cylinder parts shall be produced by:

- Using deep drawn parts and a machined plug (boss).

6.1.1

The manufacturer shall have the technical capability; the appropriate means and qualified personnel to undertake the manufacture of cylinders.

6.2 Welding procedures

The manufacturer with the agreement of the Inspection Body, before proceeding with the production of a given design of cylinder, shall approve all welding procedures to EN ISO 15607 and EN ISO 15614-1 and welders to EN 287-1. Records of such qualification shall be kept on file by the manufacturer.

6.3 Welded seams of pressure containing parts

6.3.1

The welding of the circumferential seam shall be by an automatic or semi automatic process.

6.3.2

The circumferential seam shall be butt welded as illustrated in Figure 1.

6.4 Valve protection

6.4.1

Valves shall be protected from damage, which could cause release of gas, either by the design of the cylinder (e.g. protective shroud) or a valve protection device (in accordance with EN 962).

6.4.2

When a protective shroud is used, it shall fulfil the requirements of the drop test described in EN 962.

6.5 Boss threads

The internal and external threads shall conform to a recognized standard to permit the use of a corresponding valve thus minimizing neck stresses following the valve torquing operation. Internal boss threads shall be checked using gauges corresponding to the agreed thread, or by an alternative method. Particular care shall be taken to ensure that threads are accurately cut, are of full form and free from any sharp profiles e.g. burrs.
NOTE For example, where the thread is specified to be in accordance with EN 629-1, the corresponding gauges are specified in EN 629-2.

6.6 Visual examination

6.6.1 Unacceptable defects
Before assembly, the pressure containing parts of the cylinders shall be examined for uniform quality and freedom from defects which may ultimately affect the cylinder integrity in accordance with EN1964-1:1999 and EN13322-1. Examples of defects for the drawn shell and base are given in EN 1964-1:1999 Annex B. Examples for defects in the machined end-plug are given in EN13322-1 Annex C. The surface of the metal and in particular the inner wall shall be clean, dry and free from oxidation products, corrosion and scale.

6.6.2 Welds

6.6.2.1 All welds shall have a smooth finish without concavity and shall merge into the parent material without under-cutting or abrupt irregularity. Inspection of welds shall be performed in accordance with EN13322-1.

6.6.2.2 The butt weld shall have full penetration (see Figure 1.)

Figure 1—Illustration of weld penetration.
6.6.3 Out of roundness
The out-of-roundness of the cylindrical part of the shell shall be limited so that the difference between the maximum and the minimum outside diameter in the same cross-section is not more than 2 % of the mean of these diameters.

6.6.4 Straightness
Unless otherwise specified on the manufacturing drawing, the maximum deviation of the cylindrical part of the shell from a straight line shall not exceed 0,3 % of the cylindrical length.

6.6.5 Verticality
When the cylinder is standing on its base, the cylindrical shell and concentric top opening shall be vertical to within 1 % of the cylindrical length.

7 Technical requirements for type approval testing (New Design Tests)

7.1 General requirements

7.1.1
The manufacturer shall apply to the Inspection Body for a Type Approval Certificate for each different design of cylinder. A type approval must be obtained and retained for each approved cylinder design.

A cylinder shall be considered to be of a new design compared with an existing design when:

- it is manufactured in a different factory; or

- it is manufactured by a different welding process or a radical change in an existing process, e.g. change of type of heat treatment; or

- it is manufactured from a steel of different specified chemical composition range; or

- it is given a different heat treatment outside the ranges stipulated in 4.2; or

- if there is a change in base profile, e.g. concave, convex, hemispherical, or there is a change in the base thickness/cylinder diameter ratio; or

- the guaranteed minimum yield stress (Rₑ) or guaranteed minimum tensile strength (R₉) has changed; or
- the overall length of the cylinder has increased by more than 50% (cylinders with a length/diameter ratio less than 3 shall not be used as reference cylinders for any new design with this ratio greater than 3); or
- the nominal outside diameter has changed; or
- the guaranteed minimum wall thickness \(a'\) has been decreased; or
- the hydraulic test pressure has been changed (where a cylinder is used for a lower pressure duty than that for which the cylinder was approved, it shall not be deemed a new design).

7.1.2
A technical specification of the cylinder, including design drawing, design calculations, material details, welding and manufacturing process and heat treatment, shall be prepared by the manufacturer.

7.1.3
A minimum of 50 finished cylinders, which shall be guaranteed by the manufacturer to be representative of a new design, shall be made available for type approval testing. The minimum wall thickness of the test cylinders shall not exceed 15% of the minimum guaranteed wall thickness for type approval design. For type approval testing requirements, the inspector shall select cylinders from the batch having the thinnest walls. If the total production is less than 50 cylinders, enough cylinders shall be made to complete the tests required, in addition to the production quantity. In this case the Type Approval Certificate is limited to the particular batch.

7.1.4
The Type Approval process shall include the verifications and tests listed in 7.2.1 and 7.2.2 respectively.

7.2 Verifications and tests

7.2.1 Verifications
It shall be verified that:

- the requirements of clause 4 (material) are fulfilled;
- the design conforms to the requirements of clause 5;
- the requirements of clause 6 are fulfilled for all cylinders selected;
- internal and external surfaces of the cylinders are free of any defect which may make them unsafe for use (see EN 1964-1:1999 Annex B and EN13322-1 Annex C).

7.2.2 List of tests
The following shall be performed on cylinders selected after the welds of the cylinders have been visually inspected:
- the test specified in 7.3.1 (hydraulic burst test) on three cylinders, the cylinder bearing representative stamp marking.

- the test specified in 7.3.2 (pressure cycling test) on three cylinders, the cylinder bearing representative stamp marking.

- the tests specified in 8.4 (tensile test), 8.5 (bend test), and 8.6 (macroscopic examination of weld cross-sections), on one cylinder, the test pieces being identifiable to the batch;

- tests specified in 9.1 (pneumatic pressure test).

- radiographic examination, radioscopic examination, or NDT examination carried out using another suitable method, as specified in clause 8.7 on cylinders randomly selected from the batch.

7.3 Description of tests

7.3.1 Hydraulic burst test

7.3.1.1 Cylinders subjected to this test shall bear markings in accordance with the complete stamp markings as required for the finished cylinder. The hydraulic burst test shall be carried out with equipment which enables the pressure to be increased at a controlled rate until the cylinder bursts and the change in pressure with time to be recorded.

7.3.1.2 For a test pressure \((p_h) \leq 42\) bar the burst pressure \((p_b)\) shall be at least 9/4 times the test pressure with a minimum burst pressure of 94.5 bar.

7.3.1.3 The burst test shall not cause any fragmentation of the cylinder.

7.3.1.4 The main fracture shall not show any brittleness, i.e. the edges of the fracture shall not be radial but shall be at an angle to a diametral plane and display a reduction of area throughout their thickness. The fracture shall be examined and shall be free of defects. Initiation and/or any fracture of the cylinder shall not occur at the markings.

7.3.2.5 For cylinders with a test pressure \((p_h) \leq 42\) bar, the ratio of the volumetric expansion of the cylinder to its initial volume shall be at least 20%.

7.3.2 Pressure cycling test

7.3.2.1 The pressure cycling test shall be carried out on 3 cylinders bearing stamp markings generated by the production process. The inspector shall select cylinders from the batch having the thinnest walls for the pressure cycling test.

7.3.2.2 The tests shall be carried out with a non-corrosive liquid, subjecting the cylinder to successive reversals at an upper cyclic pressure which is equal
to the hydraulic test pressure ($p_h$). The value of the lower cyclic pressure shall not exceed 10% of the upper cyclic pressure. The frequency of reversals of pressure shall not exceed 0.25 Hz (15 cycles/minute). The temperature measured on the outside surface of the cylinder shall not exceed 50ºC during the test.

7.3.2.3 The cylinder shall be subjected to 12000 cycles without leakage or failure.

7.3.2.4 On completion of pressure cycling, 2 cylinders shall be burst tested in accordance with 7.3.1. The 2 cylinders undergoing the burst test shall comply with the requirements of 7.3.1.2, 7.3.1.3, 7.3.1.4 and 7.3.1.5.

The remaining cylinder shall be sectioned to check for evidence of fatigue cracking and verification of minimum wall thickness.

8 Batch tests

8.1 General

For the purpose of carrying out the batch testing, a random sample of cylinders as indicated in Table 1 shall be taken from each batch, as defined in 3.1.4. A batch shall consist of a maximum of 200 cylinders, excluding test specimens. All batch tests shall be carried out on finished cylinders.

<table>
<thead>
<tr>
<th>Batch size</th>
<th>Number of cylinders taken as samples</th>
<th>Number of cylinders to be tested</th>
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<tr>
<td></td>
<td>Tensile test and bend test (as per 8.4 and 8.5)</td>
<td>Macroscopic examination (as per 8.6)</td>
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<tr>
<td>Up to 200 (excluding test specimens)</td>
<td>3</td>
<td>1</td>
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</tbody>
</table>
8.2 Information
For the purposes of batch testing, the manufacturer shall provide the following:

- the Type Approval Certificate;
- the certificates for the material of construction as required in 4.1.5 stating the cast analyses of the steel supplied for the construction of the cylinders;
- a list of cylinders, stating serial numbers and stamp markings as required;
- a statement of the thread checking method used and the results thereof.

8.3 Checks and verifications
The following checks and verifications shall be carried out on each batch of cylinders by the Inspection Body:

- ascertain that a Type Approval certificate has been obtained and that the cylinders conform to it;
- check whether the requirements set out in clauses 4, 5, 6 and 11 have been met, and in particular check by an external and internal examination of the cylinders whether the construction and checks carried out by the manufacturer in accordance with clause 6 are satisfactory. The visual examination shall cover at least 10% of the cylinders submitted. However, if an unacceptable defect is found (as described in EN 1964-1:1999 Annex B and EN 13322-1 Annex C) 100% of cylinders shall be visually inspected;
- carry out or witness the tests specified in 8.4 (tensile test), 8.5 (bend test), 8.6 (macroscopic examination of weld cross-sections), and 7.3.1 (hydraulic burst test) on the number of cylinders specified in 8.1;
- carry out or witness the tests specified in 9.1 (pressure test);
- check whether the information supplied by the manufacturer listed in 8.2 is correct; random checks shall be carried out;
- Assess the results of the NDT examination, as specified in clause 8.7.

8.4 Tensile test
8.4.1 General
The tensile test on parent metal shall be carried out on a test sample taken from the finished cylinder in accordance with the requirements of EN 10002-1.
The two faces of the test sample formed by the inside and the outside surfaces of the cylinder shall not be machined. The tensile test on welds shall be carried out in accordance with 8.4.3.

8.4.2 Tensile test samples required from parent material

8.4.2.1 One tensile test sample shall be cut in the longitudinal direction from the cylindrical portion of the cylinder.

8.4.2.2 The values obtained for yield stress ($R_{ea}$), tensile strength ($R_m$) and elongation (A) shall be not less than those guaranteed by the cylinder manufacturer and in accordance with those given in EN 10120 or EN 10028-1 and EN 10028-3, or EN 10028-1 and EN 10028-5, as appropriate.

8.4.3 Tensile test samples required from welds

8.4.3.1 One tensile test sample shall be taken and prepared as follows:

- The inspector shall select a shell.

- Weld an extended boss (to allow the extraction of a standard tensile test piece from the welded cylinder) to the open end of the selected shell using the same procedures and equipment as for welding the boss. The extended boss shall be made from the same material and shall have the same weld joint configuration as the boss.

8.4.3.2 All tensile tests shall be in a direction transverse to the weld. The face and root of the weld in the test sample shall be machined flush to the plate surface.

The face and back of the parent metal shall not be machined but shall represent the surface of the cylinder as manufactured. The ends only may be flattened, by cold pressing, for gripping in the test machine. The tensile strength value obtained shall be at least equal to the minimum value specified in 8.4.2.2 for the parent metal, regardless of the position of the fracture.

8.5 Bend test

8.5.1 A face bend and root bend specimen shall be prepared and tested in accordance with Figure 5 in CGA C-3-2003, Sixth Edition using the alternate guided-bend test jig shown in Figure 7.

8.5.2 Both specimens shall have passed this test if the tested pieces comply with the requirements of 8.7.3.2 of CGA C-3-2003, Sixth Edition.
8.6 Macroscopic examination of weld cross-sections

A macroscopic weld examination for each type of welding procedure shall be performed. It shall show complete fusion and shall be free of any assembly faults or unacceptable defects, as defined in EN13322-1:2003 Annex B.3.3.

8.7 Radiographic examination of welds

8.7.1
The radiographic examination shall conform to the techniques in EN 1435. Radiographs shall show complete penetration of weld and freedom from unacceptable defects. The test equipment shall be operated by personnel certified at least to level 1 of EN 473 and supervised and interpreted by personnel certified at least to Level 2.

The radiographic examination may be replaced by radioscopy, ultrasonic or another suitable method if the applied NDT method is carried out according to a process that provides the same quality of examination as radiographic examination.

8.7.2 Requirements
One cylinder at the beginning and one cylinder at the end of each shift period from each welding machine shall be radiographed. 100% of the length of the weld shall be radiographed. Another sample shall be selected and radiographed if any adjustments are made to the welding machine or welding parameters.

NOTE Initial qualification of the weld process will include determination of process capability requiring a greater sampling quantity of the batch to assure a high confidence level in the welding process. After suitable process capability has been demonstrated, the NDT sampling size can be reduced to a sample at the beginning and end of the shift period. The Inspection Body shall certify appropriate process capability prior to a reduction in sampling frequency.

8.7.3
If the radiographs show no unacceptable defects and all other batch tests are completed satisfactorily, the batch of cylinders shall be accepted.

8.7.4 Detection of defects

8.7.4.1 When defects are detected, the manufacturer shall retest the entire length of the relevant weld for each cylinder manufactured since the last radiographic examination where no defect was found. If an approved identification system is in operation, the number of cylinders to be retested may be limited to those manufactured on the identified welding equipment.

8.7.4.2 Assessment of the weld radiographs shall be based on the original films in accordance with the practice recommended in clause 6 of ISO 2504:1973.
8.7.4.3 Acceptance criteria shall be as specified to level C in EN 25817 or level 2 in EN 12517.

8.7.4.4 Production shall not be restarted until the cause of the defect has been established and rectified and a satisfactory radiograph has been obtained.

9 Tests on every cylinder

9.1 Pressure test

All cylinders in each batch shall be subjected to a pneumatic leak test using helium gas to ensure that there is no leakage from the cylinder, weld, boss or valve. During testing, the pressure in the cylinder shall be increased at a controlled rate until the test pressure is reached. The leak rate of the cylinder is determined at test pressure using a helium leak detector. The helium leak test equipment must be calibrated before each test and capable of detecting leaks of $1 \times 10^{-8}$ millibar-l/sec. Cylinders with leaks $> 1 \times 10^{-6}$ millibar-l/sec are rejected.

Note 1 Helium used for the pressure test must be ≥99.999% pure.

Note 2 The pressure test method employed must be in agreement with a competent authority as per section 6.2.1.5.1 (g) of the ADR 2005.

Note 3 Pneumatic pressure tests are more hazardous than hydrostatic tests due to the larger amount of stored energy in the test gas. Due to the potential hazards of this testing, appropriate safeguards shall be ensured by a risk assessment. At a minimum, pneumatic tests should be conducted remotely with appropriate personnel shielding or an energy adsorption barrier should be employed to contain any possible projectiles produced by a failing cylinder. Other safety precautions such as those presented in ASME B31.3 and the Health and Safety Executive publication GS4 ‘Safety in Pressure Testing’ shall be considered.

Note 4 The leak test is conducted subsequent to all other required tests and prior to dispatch.

10 Failure to meet test requirements

In the event of failure to meet test requirements, retesting or additional stress relief shall proceed as follows:

a. If there is evidence of a fault in carrying out a test or an error of measurement a further test shall be performed. If the result of this test is satisfactory, the first test shall be ignored.

b. If the test has been carried out in a satisfactory manner, the cause of test failure shall be identified.
c. if the failure is considered to be due to the stress relief applied, the manufacturer may subject all the cylinders of the batch to a further stress relieving. The conditions for the stress relief shall be the same as for the first stress relief.

d. if the failure is not due to the stress relief applied, all the identified defective cylinders shall be rejected or repaired. The repaired cylinders are then considered as a new batch.

NOTE The cylinders from the repaired batch and the remaining cylinders from the original batch are considered as two separate batches.

In both cases the new batch shall be inspected and tested. Only the relevant tests needed to prove the acceptability of the new batch shall be performed again and prove satisfactory. If one or more tests prove even partially unsatisfactory, all the cylinders of the batch shall be rejected.

11 Marking

Each cylinder shall be permanently and legibly marked on the boss as per the requirements of ADR. Each cylinder shall be marked in accordance with the drawing approved by the Inspection Body and in compliance with the requirements of ADR clause 6.2.1.7.

Each cylinder shall be marked with the approved content classification code as listed in Table P200 of the ADR (e.g. 2TF).

12 Certification

Each batch of cylinders shall be certified by the Inspection Body to the effect that the cylinders meet the requirements of this Technical Code in all respects.

The certificate shall include:

a. reference to the design code

b. the type approval certificate number

c. the batch and serial numbers of the cylinders included in the certificate

d. a statement that the cylinders have been proof pressure and leak tested in accordance with this code.
13 Periodic inspection and test

Refillable pressure receptacles shall be subjected to periodic re-inspection by an Inspection Body approved by the competent authority of the country of approval.

Periodic inspection shall be performed on each cylinder in accordance with the periodicities defined in the relevant packing instruction P200 Table 2 and the requirements of 6.2.1.6 of the ADR.

Inspection shall include:

- External visual examination of the pressure receptacle, equipment and markings using EN1968/EN1802 as a guide

Note 1 The visual examination guidelines of EN1968 and EN 1802 are to be used.

- Pressure and leak testing of the pressure receptacle and valve as per 9.1 of this technical code, and if necessary, inspection of the characteristics of the material by suitable tests.

- Inspection of the cylinder utilizing ultrasonic testing as per EN 1968 in lieu of a visual internal inspection.

Cylinders passing the test shall be marked in accordance with the current edition of the ADR.
Annex A  
(normative)

**Gases approved for carriage**

**A.1 List of gases approved for carriage**

Table A.1 lists the gases by UN number, name and description and the ADR classification code, that are approved for carriage in pressure receptacles specified by this technical code. Additionally and when applicable, the table indicates the special packaging provisions required by the ADR for each entry in the table.

**Table A.1** List of gases authorized for packaging under this technical code and the special packaging provisions required by the ADR

<table>
<thead>
<tr>
<th>UN Number</th>
<th>Name and Description</th>
<th>ADR Classification Code</th>
<th>Special Packaging Provision as Per Table 2 of P200 of the ADR</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN1008</td>
<td>Boron Trifluoride</td>
<td>2TC</td>
<td>None</td>
</tr>
<tr>
<td>UN2188</td>
<td>Arsine</td>
<td>2TF</td>
<td>d,k,r</td>
</tr>
<tr>
<td>UN2199</td>
<td>Phosphine</td>
<td>2TF</td>
<td>r,z</td>
</tr>
<tr>
<td>UN1859</td>
<td>Silicon Tetrafluoride</td>
<td>2TC</td>
<td>None</td>
</tr>
<tr>
<td>UN3308</td>
<td>Liquefied Gas, Toxic, Corrosive, N.O.S. (Germanium Tetrafluoride)</td>
<td>2TC</td>
<td>r,z</td>
</tr>
<tr>
<td>UN3308</td>
<td>Liquefied Gas, Toxic, Corrosive, N.O.S. (Arsenic Pentafluoride)</td>
<td>2TC</td>
<td>r,z</td>
</tr>
<tr>
<td>UN2198</td>
<td>Phosphorous Pentafluoride</td>
<td>2TC</td>
<td>k</td>
</tr>
<tr>
<td>UN3308</td>
<td>Liquefied Gas, Toxic, Corrosive, N.O.S. (Phosphorous Trifluoride)</td>
<td>2TC</td>
<td>r,z</td>
</tr>
<tr>
<td>UN2202</td>
<td>Hydrogen Selenide, Anhydrous</td>
<td>2TF</td>
<td>k</td>
</tr>
</tbody>
</table>
A.2 Explanation of the ADR special packaging provisions listed in Table

NOTE The provisions set out below met the requirements of the 2005 Edition of ADR. These requirements are subject to change and the user of this technical code should ensure that the current requirements of ADR are applied for each gas to be carried.

d: When steel pressure receptacles are used, only those resistant to hydrogen embrittlement shall be authorized.

NOTE As per 6.2.5.8.3 (p) of the ADR, in the case of steel pressure receptacles intended for the carriage of gases with a risk of hydrogen embrittlement, the letter “H” shall be marked on the cylinder by the cylinder manufacturer showing compatibility of the steel (see ISO 11114-1:1997)

k: Valve outlets shall be fitted with gas tight plugs or caps, which shall be made of material not liable to attack by the contents of the pressure receptacle.

Pressure receptacles shall not be fitted with a pressure relief device.

Each valve shall have a tapered threaded connection directly to the pressure receptacle and be capable of withstanding the test pressure of the pressure receptacle.

Each valve shall either be of the packless type with non-perforated diaphragm, or be of a type which prevents leakage through or past the packing.

Each pressure receptacle shall be tested for leakage after filling.

r: Not applicable to this technical code as this special provision applies only to carriage of gases in capsules
Annex B  
(informative) 

Inspection at time of fill

B.1 Conformance to existing standards

Each cylinder filled shall be inspected at the time of fill in accordance with EN 1919 or EN 1920 as appropriate.

B.2 Additional inspection at time of fill

B.2.1 Check for contamination in used cylinders

Each cylinder returned for refilling shall be analyzed by suitable means (e.g. gas chromatograph or mass spectrometer) to assure the cylinder has not been contaminated during transportation, storage or use. Cylinders contaminated with harmful levels of deleterious atmospheric impurities (i.e. water or oxygen) or other detrimental contaminants shall be removed from service and decommissioned.

B.2.2 Check for correct fill pressure

The pressure of each filled cylinder shall be verified to be less than 1 standard atmosphere at 21°C. Cylinders filled to a pressure greater than 1 standard atmosphere at 21°C (overfilled) cannot be offered for carriage. Overfilled cylinders can be reworked (e.g. controlled venting to a scrubber) in order to reduce the fill pressure to less than 1 standard atmosphere at 21°C. Cylinders that are successfully reworked can be offered for carriage.

NOTE 1 standard atmosphere = 14.7 PSIA = 760 mm Hg = 101 kPA

B.2.3 Determination of tare weight

B.2.3.1 Newly commissioned cylinders

The tare weight of new cylinders is equal to the sum of the weight of the cylinder, valve, adsorbent, any fixed valve guard and the mass of all other parts which are permanently attached (e.g. by bolted fixing or clamping and paint) to the cylinder when presented for filling. The tare weight is obtained prior to filling and subsequent to stress relief using a filling scale. The filling scale used shall have a precision-to-tolerance ratio of 0.1 and a valid calibration. Proper operation of the scale is verified each shift using a suitable calibration weight.

B.2.3.1 Used cylinders

Prior to filling, the pressure of each used cylinder shall be measured in order to determine the residual weight of adsorbed gas. The amount of residual gas
remaining in a used cylinder is related to the pressure by an isotherm. The tare weight of the cylinder is equal to the weight of the used cylinder minus the residual weight of the contents.

**B.2.4 Check for proper fill weight**
The weight of each filled cylinder shall be obtained using a filling scale. The filling scale used shall have a precision-to-tolerance ratio of 0.1 and a valid calibration. Proper operation of the scale is verified each shift using a suitable calibration weight. After obtaining the weight of the filled cylinder, the amount of gas filled is determined by subtracting the tare weight of the cylinder from the filled weight of the cylinder. The gas weight shall meet specifications derived from adsorption isotherms that assure the sub-atmospheric storage of gas within the filled cylinder.

**B.2.5 Cylinder filling records**
A database record shall be established for each filled cylinder that relates the stamped serial number on a cylinder at a minimum, to the following information:

- Fill number or cycle
- Fill date
- Required ADR cylinder retest date
- Filling location
- Fill batch or lot number
- Gas type filled
- Fill weight
- Cylinder tare weight
- Fill pressure
- Adsorbent weight
- Gas analysis information (e.g. results of analysis specified in B.2.1)

**B.2.6 Identification of cylinder for suitability for filling**
In addition to the requirements of EN 1919 or EN 1920 as appropriate, prior to refilling a cylinder it shall be verified that the gas to be filled is the same gas as previously filled. The verification shall be based on the cylinders stamped serial number and the database record described in B.2.5. This technical code requires all cylinders to be dedicated to single gas use for the entire service life of the cylinder.