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**Addendum 6**

**Chapter 6.2 of the restructured ADR**

**REQUIREMENTS FOR THE CONSTRUCTION AND TESTING OF RECEPTACLES  
FOR GASES, AEROSOLS AND SMALL RECEPTACLES CONTAINING GAS  
(GAS CARTRIDGES)**

This text is the consolidated version of Chapter 6.2 of the restructured ADR. It takes account of the outcome of the discussions at the RID/ADR/ADN Joint Meeting held from 13 to 24 March 2000 in Geneva.

## CHAPTER 6.2

### REQUIREMENTS FOR THE CONSTRUCTION AND TESTING OF RECEPTACLES FOR GASES, AEROSOLS AND SMALL RECEPTACLES CONTAINING GAS (GAS CARTRIDGES)

#### 6.2.1 General requirements for receptacles for gases

*Note:* For aerosols and small receptacles containing gas (gas cartridges) see 6.2.4

##### 6.2.1.1 *Design and construction*

6.2.1.1.1 Receptacles and their closures shall be designed, calculated, manufactured, tested and equipped in such a way as to withstand all conditions to which they will be subjected during their normal use and during normal transport conditions.

In the design of pressure receptacles, all relevant factors shall be taken into account such as:

- internal pressure;
- ambient and operational temperatures, including during transport;
- dynamic loads.

Normally the wall thickness shall be determined by calculation, accompanied, if needed, by experimental stress analysis. The wall thickness may be determined by experimental means.

Appropriate design calculations for the pressure envelope and supporting components shall be used to ensure the safety of the receptacles concerned.

The minimum wall thickness to withstand pressure shall be calculated in particular with regard to:

- the calculation pressures, which shall not be less than the test pressure;
- the calculation temperatures allowing for appropriate safety margins;
- the maximum stresses and peak stress concentrations where necessary;
- factors inherent to the properties of the material.

The test pressure of receptacles is prescribed in Packing Instruction P200 in 4.1.4.1 for cylinders, tubes, pressure drums and bundles of cylinders. The test pressure for cryogenic receptacles, closed, shall not be less than 1.3 times the maximum working pressure increased by 1 bar for vacuum insulated receptacles.

Material characteristics to be considered are, when applicable:

- yield stress;
- tensile strength;
- time-dependent strength;
- fatigue data;
- Young's modulus (modulus of elasticity);
- appropriate amount of plastic strain;
- impact strength;
- fracture resistance.

6.2.1.1.2 Receptacles for UN No.1001, dissolved acetylene, shall be filled entirely with a porous material, uniformly distributed, of a type approved by the competent authority and which:

- (a) does not attack the receptacles or form harmful or dangerous compounds either with the acetylene or with the solvent;
- (b) is capable of preventing the spread of decomposition of the acetylene in the mass.

The solvent shall not attack the receptacles.

#### **6.2.1.2 *Materials of receptacles***

The materials of which the receptacles and their closures are made as well as all substances that might come into contact with the contents shall not be liable to attack the contents or form harmful or dangerous compounds therewith.

The following materials may be used:

- (a) carbon steel for compressed, liquefied, refrigerated liquefied gases and gases dissolved under pressure;
- (b) alloy steel (special steels), nickel, nickel alloy (such as monel) for compressed, liquefied, refrigerated liquefied gases and gases dissolved under pressure;
- (c) copper for:
  - (i) gases of classification codes 1A, 1O, 1F and 1TF, whose filling pressure referred to a temperature of 15 °C does not exceed 2 MPa (20 bar);
  - (ii) gases of classification code 2A; and also UN No. 1033 dimethyl ether; UN No.1037 ethyl chloride; UN No.1063 methyl chloride; UN No.1079 sulphur dioxide; UN No.1085 vinyl bromide; UN No. 1086 vinyl chloride; and UN No.3300 ethylene oxide and carbon dioxide mixture with more than 87% ethylene oxide;
  - (iii) refrigerated liquefied gases of classification codes 3A, 3O and 3F;
- (d) aluminium alloy: see special requirement "a" of Packing Instruction P200 (I) in 4.1.4. 1;

- (e) composite material for compressed, liquefied, refrigerated liquefied gases and gases dissolved under pressure;
- (f) synthetic materials for refrigerated liquefied gases; and
- (g) glass for the refrigerated liquefied gases of classification code 3A other than UN No.2187 carbon dioxide or mixtures thereof, and gases of classification code 3O.

### **6.2.1.3 Service equipment**

#### **6.2.1.3.1 Openings**

Apart from a manhole which, if provided, shall be closed by an effective closure and apart from the necessary orifice for the removal of deposits, pressure drums shall not be equipped with more than two openings one for the filling and one for the discharge.

Cylinders and pressure drums, intended for the carriage of gases of classification code 2F may be provided with other openings intended in particular for verifying the level of the liquid and the gauge pressure.

#### **6.2.1.3.2 Fittings**

- (a) If cylinders are fitted with a device to prevent rolling, this device shall not be integral with the valve cap;
- (b) Pressure drums which are capable of being rolled shall be equipped with rolling hoops or be otherwise protected against damage due to rolling (e.g. by corrosion - resistant metal sprayed on to the receptacle surface);
- (c) Pressure drums and cryogenic receptacles, which are not capable of being rolled, shall be fitted with devices (skids, rings, straps,) ensuring that they can be safely handled by mechanical means and so arranged as not to impair the strength of, nor cause undue stresses in, the wall of the receptacle;
- (d) Bundles of cylinders shall be fitted with appropriate devices ensuring that they can be handled and transported safely. The manifold shall have at least the same test pressure as the cylinders. The manifold and the master cock shall be situated so as to be protected against any damage.

#### **6.2.1.3.3 Safety valves**

Cryogenic receptacles, closed, shall be fitted with one or more pressure relief devices to protect the vessel against excess pressure. Excess pressure means a pressure in excess of 110% of the maximum working pressure due to normal heat leak or in excess of the test pressure due to the loss of vacuum for vacuum insulated receptacles or due to the failure in the open position of a pressure build up system.

#### 6.2.1.4 *Approval of receptacles*

6.2.1.4.1 The conformity of receptacles, having a test pressure capacity product of more than 150 MPa.litre (1500 bar.litre) with the provisions of Class 2, shall be assessed by one of the following methods:

- (a) Single receptacles shall be examined, tested and approved by a testing and certifying body approved by the competent authority of the country of approval 1/, on the basis of the technical documentation and declaration of the manufacturer on compliance with the relevant provisions of this Class.  
The technical documentation shall include full specifications on design and construction, and full documentation on the manufacturing and testing; or
- (b) The construction of the receptacles shall be tested and approved by a testing and certifying body approved by the competent authority of the country of approval 1/ on the basis of the technical documentation with regard to their compliance with the relevant provisions of this Class.  
Receptacles shall furthermore be designed, manufactured and tested according to a comprehensive quality assurance programme for design, manufacture, final inspection and testing. The quality assurance programme shall guarantee the conformity of the receptacles with the relevant provisions of this Class and shall be approved and supervised by a testing and certifying body approved by the competent authority of the country of approval 1/; or
- (c) The design type of the receptacles shall be approved by a testing and certifying body approved by the competent authority of the country of approval 1/. Any receptacle of this design shall be manufactured and tested according to a quality assurance programme for production, final inspection and testing, which shall be approved and supervised by a testing and certifying body approved by the competent authority of the country of approval 1/; or
- (d) The design type of the receptacles shall be approved by a testing and certifying body approved by the competent authority of the country of approval 1/. Any receptacle of this design shall be tested under the supervision of a testing and certifying body approved by the competent authority of the country of approval 1/ on the basis of a declaration of the manufacturer on compliance with the approved design and the relevant provisions of this Class.

6.2.1.4.2 The conformity of receptacles having a test pressure capacity product of more than 30MPa.litre (300 bar.litre) and not more than 150 MPa.litre (1500 bar.litre) with the provisions of Class 2 shall be assessed by one of the methods described in 6.2.1.4.1 or by one of the following methods:

- (a) The receptacles shall be designed, manufactured and tested according to a comprehensive quality assurance programme for their design, manufacture, final

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*1/ If the country of approval is not a contracting party to ADR, the competent authority of a country party to ADR.*

inspection and testing, approved and supervised by a testing and certifying body approved by the competent authority of the country of approval 1/; or

- (b) The design type of the receptacle shall be approved by a testing and certifying body approved by the competent authority of the country of approval 1/. The compliance of any receptacle with the approved design shall be declared in writing by the manufacturer on the basis of his quality assurance programme for final inspection and testing of receptacles, approved and supervised by a testing and certifying body approved by the competent authority of the country of approval 1/; or
- (c) The design type of the receptacle shall be approved by a testing and certifying body approved by the competent authority of the country of approval 1/. The compliance of any receptacle with the approved design shall be declared in writing by the manufacturer and all receptacles of this type shall be tested under the supervision of a testing and certifying body approved by the competent authority of the country of approval 1/.

6.2.1.4.3 The conformity of receptacles, having a test pressure capacity product of not more than 30 MPa.litre (300 bar.litre) with the provisions of Class 2 shall be assessed by one of the methods described in 6.2.1.4.1 or 6.2.1.4.2 or by one of the following methods:

- (a) The compliance of any receptacle with a design, fully specified in technical documentation, shall be declared in writing by the manufacturer and receptacles of this design shall be tested under the supervision of a testing and certifying body approved by the competent authority of the country of approval 1/; or
- (b) The design type of the receptacles shall be approved by a testing and certifying body approved by the competent authority of the country of approval 1/. The compliance of all receptacles with the approved design shall be declared in writing by the manufacturer and all receptacles of this type shall be tested individually.

6.2.1.4.4 The requirements of 6.2.1.4.1 to 6.2.1.4.3 shall be deemed to be complied with:

- (a) as regards the quality assurance systems mentioned in 6.2.1.4.1 and 6.2.1.4.2, if they conform to the relevant European Standard of the EN ISO 9000 series;
- (b) in their entirety, if the relevant conformity assessment procedures of Council Directive 99/36/EC 2/ have been complied with as follows:
  - (i) for the receptacles listed under 6.2.1.4.1 the modules G, or H1, or B in combination with D, or B in combination with F;

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1/ *If the country of approval is not a contracting party to ADR, the competent authority of a country party to ADR.*

2/ *Council Directive 99/36/EC concerning transportable pressure equipment (Official Journal of the European Communities, No. L138 of 1 June 1999)*

(ii) for the receptacles listed under 6.2.1.4.2 the modules H, or B in combination with E, or B in combination C1, or B1 in combination with F, or B1 in combination with D;

(iii) for the receptacles listed under 6.2.1.4.3 the modules A1, or D1, or E1.

#### 6.2.1.4.5 *Requirements for manufacturers*

The manufacturer shall be technically competent and shall possess all suitable means required for the satisfactory manufacture of receptacles; this relates in particular to qualified personnel

- (a) to supervise the entire manufacturing process;
- (b) to carry out joining of materials;
- (c) to carry out the relevant tests;

The proficiency test of a manufacturer shall in all instances be carried out by a testing and certifying body approved by the competent authority of the country of approval<sup>1</sup>/. The particular certification process the manufacturer intends to apply shall be taken into consideration.

#### 6.2.1.4.6 *Requirements for testing and certifying bodies*

Testing and certifying bodies shall be independent from manufacturing enterprises and technologically competent to the degree required. These requirements shall be deemed to be met if the bodies have been approved on the basis of an accreditation procedure in accordance with the relevant European standards of series EN 45 000.

#### **6.2.1.5 *Initial inspection***

6.2.1.5.1 Receptacles shall be subjected to initial inspection in accordance with the following specifications:

On an adequate sample of receptacles:

- (a) Testing of the material of construction in respect at least of yield stress, tensile strength, and permanent elongation at fracture;
- (b) Measurement of wall thickness at the thinnest point, and calculation of the stress;
- (c) Checking the homogeneity of the material for each manufacturing batch, and inspection of the external and internal condition of the receptacles;

For all receptacles:

- (d) A hydraulic pressure test. Receptacles shall withstand the test pressure without undergoing permanent deformation or exhibiting cracks;

**NOTE:** *With the agreement of the testing and certifying body approved by the competent authority of the country of approval 1/, the hydraulic pressure test may be replaced by a test using a gas, where such operation does not entail any danger.*

- (e) An inspection of the markings on the receptacles, see 6.2.1.7;
- (f) In addition, receptacles intended for the carriage of UN No. 1001 acetylene, dissolved, shall have an inspection of the nature of the porous material and the quantity of solvent.

#### 6.2.1.5.2 *Specific provisions applying to aluminium alloy receptacles*

- (a) In addition to the tests required by 6.2.1.5.1, it is necessary to test for possible intercrystalline corrosion of the inside wall of the receptacles where use is made of an aluminium alloy containing copper, or where use is made of an aluminium alloy containing magnesium and manganese and the manganese content is greater than 3.5% or the manganese content lower than 0.5%.
- (b) In the case of an aluminium/copper alloy the test shall be carried out by the manufacturer at the time of approval of a new alloy by the competent authority; it shall thereafter be repeated in the course of production, for each pour of the alloy.
- (c) In the case of an aluminium/magnesium alloy the test shall be carried out by the manufacturer at the time of approval of a new alloy and of the manufacturing process by the competent authority. The test shall be repeated whenever a change is made in the composition of the alloy or in the manufacturing process.

#### 6.2.1.6 *Periodic inspection*

6.2.1.6.1 Refillable receptacles shall be subjected to periodic inspections under the supervision of a testing and certifying body approved by the competent authority of the country of approval 1/, in accordance with the periodicities defined in the relevant packing instruction (P200 or P203 in 4.1.4.1) and in accordance with the following specifications:

- (a) Check of the external condition of the receptacle and verification of the equipment and the markings;
- (b) Check of the internal condition of the receptacle (e.g. by weighing, internal inspection, checks of wall thickness);
- (c) The hydraulic pressure test and, if necessary, verification of the characteristics of the material by suitable tests;

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1/ *If the country of approval is not a contracting party to ADR, the competent authority of a country party to ADR.*



**NOTE 1:** *With the agreement of the testing and certifying body approved by the competent authority of the country of approval 1/, the hydraulic pressure test may be replaced by a test using a gas, where such operation does not entail any danger, or by an equivalent method based on ultrasound.*

**NOTE 2:** *With the agreement of the testing and certifying body approved by the competent authority of the country of approval 1/, the hydraulic pressure test of cylinders and tubes may be replaced by an equivalent method based on acoustic emission.*

**NOTE 3:** *With the agreement of the testing and certifying body approved by the competent authority of the country of approval 1/, the hydraulic pressure test of each welded steel cylinder intended for the carriage of gases, UN No.1965, with a capacity below 6,5l may be replaced by another test ensuring an equivalent level of safety.*

6.2.1.6.2 For receptacles intended for the carriage of UN No.1001 acetylene, dissolved, only the external condition (corrosion, deformation) and the condition of the porous mass (loosening, settlement) shall be examined.

6.2.1.6.3 By derogation from 6.2.1.6.1(c) closed cryogenic receptacles shall be subjected to external inspection and to a leakproofness test. The leakproofness test shall be carried out with the gas contained in the receptacle or with an inert gas. Checking shall be performed by means of a pressure gauge or by vacuum measurement. The thermal insulation need not be removed.

#### **6.2.1.7 Marking of receptacles**

6.2.1.7.1 Refillable receptacles shall bear the following particulars in clearly legible and durable characters:

- (a) The name or the mark of the manufacturer;
- (b) The approval number (if the design type of the receptacle is approved according to 6.2.1.4);
- (c) The serial number of the receptacle provided by the manufacturer;
- (d) The tare of the receptacle without fittings and accessories, when the check of wall thickness required during the periodic inspection is performed by weighing;
- (e) The test pressure;
- (f) The date (month and year) of the initial inspection and the most recent periodic inspection;

**NOTE:** *The month need not be indicated for gases for which the interval between periodic inspection is 10 years or more (see 4.1.4.1 Packing Instructions P200 (i) and P203 (h)).*

- (g) The stamp of the expert who carried out the tests and inspections;
- (h) In the case of UN No.1001 acetylene, dissolved: the permitted filling pressure (see 4.1.4.1, Packing Instruction P200 (f)) and the total of the mass of: the empty receptacle, the fittings and accessories, the porous mass and the solvent;
- (i) The water capacity in litres;
- (j) For compressed gases filled by pressure, the maximum filling pressure at 15 °C allowed for the receptacle;

These marks shall be immovably affixed, e.g. engraved, either on a reinforced part of the receptacle, on a ring, or on immovably affixed attachments.

They can also be engraved on the receptacle directly, provided it can be demonstrated that the strength of the receptacle is not impaired by the marking.

**NOTE:** *see also 5.2.1.6*

6.2.1.7.2 Non-refillable receptacles shall bear the following particulars in clearly legible and durable characters:

- (a) The name or the mark of the manufacturer;
- (b) The approval number (if the design type of the receptacle is approved according to 6.2.1.4);
- (c) The serial or batch number of the receptacle provided by the manufacturer;
- (d) The test pressure;
- (e) The date (month and year) of manufacture;
- (f) The stamp of the expert who carried out the initial inspection;
- (g) The UN number and the proper shipping name as determined in accordance with Chapter 3.1;

In the case of gases classified under an N.O.S. entry, only the UN number and the technical name 3/ of the gas have to be indicated;

In the case of mixtures, not more than the two constituents which most predominantly contribute to the hazards have to be indicated;

- (h) The words "DO NOT REFILL"; this marking shall be a minimum of 6 mm in height.

The marks mentioned in this paragraph, other than (g), shall be immovably affixed, e.g. engraved, either on a reinforced part of the receptacle, on a ring, or on immovably affixed attachments.

They can also be engraved on the receptacle directly, provided it can be demonstrated that the strength of the receptacle is not impaired by the marking.

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3/ *Instead of the technical name the use of one of the following names is permitted:*

- *For UN No. 1078 refrigerant gas, N.O.S.: mixture F1, mixture F2, mixture F3;*
- *For UN No. 1060 methylacetylene and propadiene mixtures, stabilized: mixture P1, mixture P2;*
- *For UN No. 1965 hydrocarbon gas mixture, liquefied, N.O.S.: mixture A or butane, mixture A01 or butane, mixture A02 or butane, mixture A0 or butane, mixture A1, mixture B1, mixture B2, mixture B, mixture C or propane.*

## 6.2.2 Receptacles designed, constructed and tested according to standards

The requirements of 6.2.1 are considered to have been complied with if the following standards, as relevant, are applied:

Reference	Title of document	Applicable sections
<i>for materials</i>		
EN 1797-1:1998	Cryogenic vessels-Gas/material compatibility-Part 1: Oxygen compatibility	6.2.1.2
EN ISO 11114-1:1997	Compatibility of cylinder and valve materials with gas contents-Part 1: Metallic materials	6.2.1.2
[prEN ISO 11114-2	Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents- Part 2: Non-metallic materials	6.2.1.2]
EN 1252-1: 1998	Cryogenic vessels-Materials-Part 1: Toughness requirements for temperature below $-80^{\circ}\text{C}$	6.2.1.2
<i>for cylinders</i>		
Annex I, Parts 1 to 3 to 84/525/EEC	Council directive on the approximation of the laws of the Member States relating to seamless steel gas cylinders	6.2.1.1 and 6.2.1.5
Annex I, Parts 1 to 3 to 84/526/EEC	Council directive on the approximation of the laws of the Member States relating to welded unalloyed steel gas cylinders	6.2.1.1 and 6.2.1.5
Annex I, Parts 1 to 3 to 84/527/EEC	Council directive on the approximation of the laws of the Member States relating to seamless, unalloyed aluminium and aluminium alloy gas cylinders	6.2.1.1 and 6.2.1.5
EN 1442:1998	Transportable refillable welded steel cylinders for LPG - Design and construction	6.2.1.1, 6.2.1.5, 6.2.1.7
EN 1800:1998	Acetylene cylinders- Basic requirements and definitions	6.2.1.1.2
EN 1964-1:1999	Seamless steel gas cylinders: $0.5\text{ l} < \text{capacity} \leq 150\text{ l}$	6.2.1.1 and 6.2.1.5
EN 1975:1999 except Annex G	Seamless aluminium alloy gas cylinders: $0.5\text{ l} < \text{capacity} \leq 150\text{ l}$	6.2.1.1 and 6.2.1.5
EN ISO 11120:1999	Seamless gas cylinders: $150\text{ l} < \text{capacity} < 3000\text{ l}$	6.2.1.1 and 6.2.1.5
[prEN 1964-3	Transportable gas cylinders-Specification for the design and construction of refillable transportable seamless steel gas cylinders of capacity from 0.5 litre up to 150 litre- Part 3: Cylinders made of stainless steel	6.2.1.1 and 6.2.1.5
[prEN 12205	Transportable gas cylinders- Non refillable metallic gas cylinders	6.2.1.1 and 6.2.1.5]
prEN 1251-1	Cryogenic vessels- Transportable, vacuum insulated, of not more than 1000 litres volume- Part 1: Fundamental requirements	6.2.1.7.1

Reference	Title of document	Applicable sections
prEN 1251-2	Cryogenic vessels- Transportable, vacuum insulated, of not more than 1000 litres volume- Part 2: Design, fabrication, inspection	6.2.1.1 and 6.2.1.5
prEN 1251-3	Cryogenic vessels- Transportable, vacuum insulated, of not more than 1000 litres volume- Part 3: Operational requirements	6.2.1.6
<i>for closures</i>		
EN 849:1996 (except Annex A)	Transportable gas cylinders -Cylinder valves- Specification and type testing	6.2.1.1.
<i>for markings</i>		
EN 1089-1: 1996	Transportable gas cylinders - Gas cylinder identification (excluding LPG) - Part 1: Stamp marking	6.2.1.7.1 except (b) and 6.2.1.7.2 except (b)

### 6.2.3 Requirements for receptacles not designed, constructed and tested according to standards

Receptacles not designed, constructed and tested according to standards listed in the table of 6.2.2 shall be designed, constructed and tested in accordance with the provisions of a technical code providing the same level of safety and recognised by the competent authority. The requirements of 6.2.1 and the following requirements however shall be met

#### 6.2.3.1 *Metal cylinders, tubes, pressure drums and bundles of cylinders*

At the test pressure, the stress in the metal at the most severely stressed point of the receptacle shall not exceed 77% of the guaranteed minimum yield stress (Re).

"yield stress" means the stress at which a permanent elongation of 2 per thousand (i.e. 0.2%) or, for austenitic steels, 1% of the gauge length on the test-piece, has been produced.

**NOTE:** *In the case of sheet-metal the axis of the tensile test-piece shall be at right angles to the direction of rolling. The permanent elongation at fracture, shall be measured on a test-piece of circular cross-section in which the gauge length  $l$  is equal to five times the diameter  $d$  ( $l=5d$ ); if test pieces of rectangular cross-section are used, the gauge length  $l$  shall be calculated by the formula:*

$$L = 5.65\sqrt{F_0}$$

*where  $F_0$  indicates the initial cross-sectional area of the test-piece*

Receptacles and their closures shall be made of suitable materials which shall be resistant to brittle fracture and to stress corrosion cracking between -20 °C and +50 °C.

For welded receptacles only materials of faultless weldability whose adequate impact strength at an ambient temperature of -20 °C can be guaranteed, particularly in the weld seams and the zones adjacent thereto, shall be used.

Welds shall be skilfully made and shall afford the fullest safety.

Any additional thickness to allow for corrosion shall not be taken into consideration in calculating the thickness of the walls.

**6.2.3.2 Additional provisions relating to aluminium-alloy receptacles for compressed gases, liquefied gases, gases dissolved under pressure and non pressurized gases subject to special requirements (gas samples) as well as articles containing gas under pressure other than aerosols and small receptacles containing gas (gas cartridges)**

6.2.3.2.1 The materials of aluminium-alloy receptacles which are to be accepted shall satisfy the following requirements:

	A	B	C	D
Tensile strength, Rm, in MPa (=N/mm <sup>2</sup> )	49 to 186	196 to 372	196 to 372	343 to 490
Yield stress, Re, in MPa (=N/mm <sup>2</sup> ) (permanent set λg = 0.2 %)	10 to 167	59 to 314	137 to 334	206 to 412
Permanent elongation at fracture (l = 5d) in per cent	12 to 40	12 to 30	12 to 30	11 to 16
Bend test (diameter of former d = n e, where e is the thickness of the test piece)	n=5(Rm ≤ 98) n=6(Rm >98)	n=6(Rm ≤ 325) n=7(Rm >325)	n=6(Rm ≤ 325) n=7(Rm >325)	n=7(Rm ≤ 392) n=8(Rm >392)
Aluminium Association Series Number <sup>4/</sup>	1 000	5 000	6 000	2 000

<sup>4/</sup> See "Aluminium Standards and Data", Fifth edition, January 1976, published by the Aluminium Association, 750 Third Avenue, New York.

The actual properties will depend on the composition of the alloy concerned and on the final treatment of the receptacle, but whatever alloy is used the thickness of the receptacle shall be calculated by one of the following formulae:

$$e = \frac{P_{MPa} D}{\frac{2 Re}{1.3} + P_{MPa}} \quad \text{or} \quad e = \frac{P_{bar} D}{\frac{20 Re}{1.3} + P_{bar}}$$

where e = minimum thickness of receptacle wall, in mm;

$P_{MPa}$  = test pressure, in MPa

$P_{bar}$  = test pressure, in bar

D = nominal external diameter of the receptacle, in mm; and

Re = guaranteed minimum proof stress with 0.2 % proof stress, in MPa  
(=N/mm<sup>2</sup>)

In addition, the value of the minimum guaranteed proof stress (Re) introduced into the formula is in no case to be greater than 0.85 times the guaranteed minimum tensile strength (Rm), whatever the type of alloy used.

**NOTE 1:** *The above characteristics are based on previous experience with the following materials used for receptacles.*

*Column A: Aluminium, unalloyed, 99.5 g pure,*

*Column B: Alloys of aluminium and magnesium,*

*Column C: Alloys of aluminium, silicon and magnesium, such as ISO/R209-Al-Si-Mg (Aluminium Association 6351);*

*Column D: Alloys of aluminium, copper and magnesium.*

**NOTE 2:** *The permanent elongation at fracture is measured by means of test pieces of circular section in which the gauge length l is equal to five times the diameter d (l= 5d); if test-pieces of rectangular section are used the gauge length shall be calculated by the formula:*

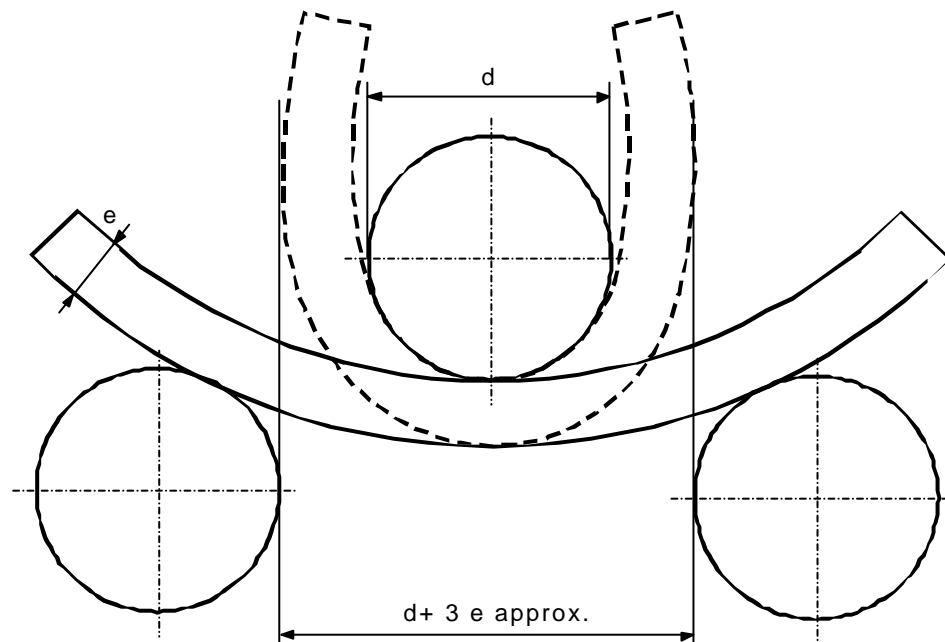
$$L = 5.65\sqrt{Fo}$$

*where Fo is the initial cross-sectional area of the test-piece.*

- NOTE 3:**
- (a) *The bend test (see diagram) shall be carried out on specimens obtained by cutting into two equal parts of width 3e, but in no case less than 25 mm, an annular section of a cylinder. The specimens shall not be machined elsewhere than on the edges.*
  - (b) *The bend test shall be carried out between a mandrel of diameter (d) and two circular supports separated by a distance of (d + 3e). During the test the inner faces shall be separated by a distance not greater than the diameter of the mandrel.*

- (c) *The specimen shall not exhibit cracks when it has been bent inwards around the mandrel until the inner faces are separated by a distance not greater than the diameter of the mandrel.*
- (d) *The ratio (n) between the diameter of the mandrel and the thickness of the specimen shall conform to the values given in the table.*

**Diagram of bend test**



6.2.3.2.2 A lower minimum elongation value is acceptable on condition that an additional test approved by the competent authority of the country in which the receptacles are made proves that safety of carriage is ensured to the same extent as in the case of receptacles constructed to comply with the characteristics given in the table in 6.2.3.2.1 (see also annex G of EN 1975: 1999).

6.2.3.2.3 The wall thickness of the receptacles at the thinnest point shall be the following:  
where the diameter of the receptacle is less than 50 mm: not less than 1.5 mm;

- where the diameter of the receptacle is from 50 to 150 mm: not less than 2 mm; and
- where the diameter of the receptacle is more than 150 mm: not less than 3 mm.

6.2.3.2.4 The ends of the receptacles shall have a semicircular, elliptical or "basket-handle" section; they shall afford the same degree of safety as the body of the receptacle.



### **6.2.3.3 Receptacles in composite materials**

For composite cylinders, tubes, pressure drums and bundles of cylinders which make use of composite materials i.e. comprising a liner hoop wrapped or fully wrapped with reinforcement material, the construction shall be such that a minimum burst ratio (burst pressure divided by test pressure) is

- 1.67 for hoop wrapped receptacles
- 2.00 for fully wrapped receptacles

### **6.2.3.4 Closed cryogenic receptacles**

The following requirements apply to the construction of closed cryogenic receptacles for refrigerated liquefied gases:

6.2.3.4.1 All the mechanical and technological characteristics of the metal used shall be established for each receptacle at the initial inspection; with regard to the impact strength;

6.2.3.4.2 If other materials are used, they shall resist brittle fracture at the lowest working temperature of the receptacle and its fittings;

6.2.3.4.3 Receptacles shall be fitted with a safety valve which shall be capable of opening at the working pressure shown on the receptacle. The valves shall be so constructed as to work perfectly even at their lowest working temperature. Their reliability of functioning at that temperature shall be established and checked by testing each valve or a sample of valves of the same type of construction;

6.2.3.4.4 The vents and safety valves of receptacles shall be so designed as to prevent the liquid from splashing out;

6.2.3.4.5 Receptacles whose filling is measured by volume shall be provided by a level indicator;

6.2.3.4.6 The receptacles shall be thermally insulated. The thermal insulation shall be protected against impact by means of continuous pressure envelope. If the space between the receptacle and the pressure envelope is airless (vacuum-insulation), the protective pressure envelope shall be designed to withstand without deformation an external pressure of at least 100 kPa (1 bar). If the pressure envelope is so closed as to be gas-tight (e.g. in the case of vacuum-insulation), a device shall be provided to prevent any dangerous pressure from developing in the insulating layer in the event of inadequate gas-tightness of the receptacle or its fittings. The device shall prevent moisture from penetrating into the insulation.

## **6.2.4 General requirements for aerosols and small receptacles containing gas (gas cartridges)**

### **6.2.4.1 Design and construction**

6.2.4.1.1 Aerosol dispensers (UN No.1950 aerosols) containing only a gas or a mixture of gases, and UN No.2037 small recipients containing gas (gas cartridges), shall be made of metal. This requirement shall not apply to aerosols and small receptacles containing gas (gas cartridges) with a maximum capacity of 100 ml for UN No. 1011 butane. Other aerosol dispensers (UN No.1950

aerosols) shall be made of metal, synthetic material or glass. Receptacles made of metal and having an outside diameter of not less than 40 mm shall have a concave bottom.

6.2.4.1.2 The capacity of receptacles made of metal shall not exceed 1000 ml; that of receptacles made of synthetic material or of glass shall not exceed 500 ml.

6.2.4.1.3 Each model of receptacles (aerosols or cartridges) shall, before being put into service, satisfy a hydraulic pressure test carried out in conformity with 6.2.4.2.

6.2.4.1.4 The release valves and dispersal devices of aerosol dispensers (UN No.1950 aerosols) and the valves of UN No.2037 small recipients containing gas (gas cartridges) shall ensure that the receptacles are so closed as to be leakproof and shall be protected against accidental opening. Valves and dispersal devices which close only by the action of the internal pressure are not to be accepted.

#### **6.2.4.2 *Initial testing***

6.2.4.2.1 The internal pressure to be applied (test pressure) shall be 1.5 times the internal pressure at 50°C, with a minimum pressure of 1 MPa (10 bar);

6.2.4.2.2 The hydraulic pressure tests shall be carried out on at least five empty receptacles of each model;

- (a) until the prescribed test pressure is reached, by which time no leakage or visible permanent deformation shall have occurred; and
- (b) until leakage or bursting occurs; the dished end, if any, shall yield first and the receptacle shall not leak or burst until a pressure 1.2 times the test pressure has been reached or passed.

#### **6.2.4.3 *Reference to standards***

The requirements of this paragraph are deemed to be met if the following standards are complied with:

- for aerosol dispensers (UN No. 1950 aerosols): Annex to Council Directive 75/324/EEC as amended by Commission Directive 94/1/EC;
- for UN No.2037 small recipients containing gas (gas cartridges) containing UN No. 1965 hydrocarbon gas mixture n.o.s, liquefied: EN 417:1992 Non-refillable metallic gas cartridges for liquefied petroleum gases, with or without a valve, for use with portable appliances - Construction, inspection, testing and marking.