



**Recognized technical code
(Anerkanntes Technisches Regelwerk, ATR)**

for the construction, equipment, test, approval and marking as transportable pressure equipment of composite tubes with a seamless, with a hoop-wrapped and load sharing liner made of metallic materials, of a working pressure not exceeding 50 MPa (500 bar) and a water capacity not exceeding 450 L

(ATR D 2/10)

Based on Section 8 No 10 of the Ordinance on the Transport of Dangerous Goods by Road, Rail and Inland Waterways (GGVSEB) of 17 June 2009 (Federal Law Gazette I p. 1389) as amended by the Ordinance of 4 March 2011 (Federal Law Gazette I, p. 347), the Federal Institute for Materials Research and Testing (BAM) in agreement with the Federal Ministry of Transport, Building and Urban Development promulgates, in accordance with section 6.2.5 of RID and ADR¹, the recognized technical code for the construction, equipment, test, approval and marking of portable hoop-wrapped composite tubes with a seamless liner made of metallic materials (ATR D 2/10) as set out below.

The Federal Institute for Material Research and Testing promulgates this ATR also based on Section 6 paragraph 5 of the Transport of Dangerous Goods by Sea Ordinance in the version promulgated on 22 February 2010 (Federal Law Gazette I, p. 238) as amended by Article 2 of the Ordinance of 3 August 2010 (Federal Law Gazette I p. 1139) in conjunction with section 6.2.3.1 of the IMDG Code².

The present ATR may be applied from the date of its publication in the Federal Ministry of Transport Gazette. The Federal Ministry of Transport, Building and Urban Development will submit this ATR to the competent OTIF and UNECE³ Secretariats in accordance with section 6.2.5 of RID/ADR.

The present ATR may be applied to the approval of composite tubes for carriage by rail, road, inland waterways and sea. It may only be applied to air transport if the competent authority in accordance with air traffic provisions has given permission to do so in writing.

1 Introduction

This technical Code serves the conformity assessment and approval of composite tubes with a working pressure not exceeding 50 MPa (500 bar) and a water capacity not exceeding 450 litres in accordance with section 6.2.5 of RID/ADR.

¹ RID = Regulations governing the international carriage of dangerous goods by rail
ADR = European Agreement concerning the international carriage of dangerous goods by road

² IMDG Code = International Maritime Dangerous Goods Code

³ OTIF = Intergovernmental Organisation for International Carriage by Rail (Bern)
ECE = United Nations Economic Commission for Europe (Geneva)

In accordance with the definition in 1.2.1 of RID/ADR, the water capacity of cylinders is limited to a maximum of 150 litres. Pressure receptacles of the size envisaged in this Code of a water capacity not exceeding 450 litres shall be designated and approved as tubes in accordance with 1.2.1 of RID/ADR.

As there is no reference to a specific standard for composite tubes in the table in 6.2.4 of RID/ADR 2009, a technical code to be recognized under 6.2.5 of RID/ADR is required until the international standard ISO 11515, which is currently being prepared, has been published and incorporated into the table in 6.2.4 of RID/ADR.

This ATR ensures a high level of safety which is at least equivalent to the safety level of cylinders under the currently referenced standard EN 12257:2002 "Transportable gas cylinders – Seamless, hoop-wrapped composite cylinders".

2 Scope

- 2.1 The present ATR applies to the construction, equipment, test, approval and marking of hoop-wrapped composite tubes up to a maximum permissible working pressure of 50 MPa (500 bar) and a water capacity of not more than 450 litres which have a seamless liner made of metallic material which is reinforced by a wound composite consisting of carbon fibres embedded in a matrix.
- 2.2 The composite tubes shall be constructed, equipped, tested, approved and marked in accordance with the Ordinance on portable pressure equipment – OrtsDruckV – Article 1 of the Ordinance of 17 December 2004 (Federal Law Gazette I, p. 3711) as amended by Article 3 of the 5th Ordinance of 3 August 2010 amending ordinances on the transport of dangerous goods (Federal Law Gazette I p. 1389) in conjunction with section 6.2.5 of RID/ADR, section 6.2.3 of the IMDG Code and the present ATR.
- 2.3 A conformity reassessment under OrtsDruckV in conjunction with TPED of composite tubes placed on the market before the promulgation of the present ATR shall only be permitted if the requirements of the present ATR are met. If tests for determining the data basis for comparisons between samples within the framework of periodic inspections and tests intended to determine long-time burst behaviour and long-term durability of the composite tubes have not been carried out before, they shall be carried out for the first time prior to the reassessment.
- 2.4 For the use of composite tubes for the carriage of gases by rail, road or inland waterways in accordance with the present ATR, the provisions of GGVSEB, OrtsDruckV and RID/ADR shall apply. For transport by sea, instead of the provisions of GGVSEB, the provisions of GGVSee, OrtsDruckV and the IMDG Code shall be applicable.

3 Specifications for the materials, design, manufacture and testing of composite tubes

3.1 Definitions

Within the framework of the present Code, the definitions and characters (symbols) of section 3 of standard EN 12257:2002 shall apply.

3.2 General requirements

Composite tubes shall comply with the requirements of sections 6.2.1, 6.2.3 and 6.2.5 of RID/ADR and the provisions of EN 12257:2002 "Transportable gas cylinders – Seamless, hoop-wrapped composite cylinders", unless variations are permitted or stipulated in the following.

3.3 Material requirements

- 3.3.1 In addition to the provisions of sub-section 6.2.5.1 of RID/ADR, the requirements and specifications in section 4 of standard EN 12257:2002 shall be complied with.

The metal liner shall be manufactured in accordance with the standards referenced in EN 12257:2002. The sections of the standard on materials, thermal treatments, neck design, construction and workmanship as well as mechanical tests shall be applied.

- 3.3.2 By derogation from the above provision, the manufacturer shall determine and document the requirements according to the type and design of the composite tube.
- 3.3.3 The compatibility of the liner material with the gases intended for filling shall be demonstrated in accordance with EN ISO 11114-1.

3.4 Design of the composite tubes

The composite tubes shall be designed in accordance with EN 12257:2002.

3.5 Manufacture

The requirements and specifications of EN 12257:2002, sections 4.4.2 (Autofrettage) and 4.4.3 (Manufacturing requirements), shall be complied with.

3.6 Tests

- 3.6.1 The following tests shall be carried out in accordance with section 5 of standard EN 12257:2002:

- Test 1: Composite material tests in accordance with section 5.2.1;
- Test 2: Test of the liner material in accordance with section 5.2.2;
- Test 3: Liner burst test at ambient temperature in accordance with section 5.2.3;
- Test 4: Hydraulic (proof) test of finished tubes at ambient temperature in accordance with section 5.2.4;
- Test 5: Burst test in accordance with section 5.2.5;

The test shall be carried out at ambient conditions and, by derogation from the above provision, the temperature on the external surface of the tube shall be maintained at less than 35 °C. The rate of pressurisation shall be plotted during the test and shall not exceed 20% PH/min.

- Test 6: Resistance to pressure cycles in accordance with section 5.2.6;
- By derogation from the above provision, the cycle tests shall be carried out at ambient conditions and on three test samples. The temperature of the external surface of the tube and of the medium shall not exceed 40 °C during the test. The cycle frequency shall only exceed 5 cycles per minute if it is ensured by means of pressure measurement at the second opening that the requirements as regards the maximum values for the lower pressure level and the minimum values for the upper pressure

level of the pressure cycles in the sample are complied with. The test shall be carried out on three samples and may be terminated after 48,000 cycles (pressure cycles to test pressure PH) or in the event of failure. The criteria for non-limited and limited life under section 5.2.6 a) or b) as well as Figure 1 of EN 12257:2002 shall be applied unaltered;

Test 7: Immersion in salt water in accordance with section 5.2.7;

By derogation from the above provision, this test is required for composite tubes intended for maritime use or the installation in vehicles (e.g. battery vehicles and MEGC);

Test 8: Exposure to elevated temperature at test pressure in accordance with section 5.2.8;

By derogation from the above provision, cycle tests in accordance with Test 6 (see above) shall be carried out instead of the concluding burst tests (Test 5). The test shall be carried out on two test samples and may be terminated after 50,000 cycles to test pressure (PH) or in the event of failure. For the joint analysis of both samples, the following criterion shall apply: The logarithmic - arithmetic mean of the number of cycles to failure shall be at least two thirds of the logarithmic - arithmetic mean of the three cycle results determined in Test 6. For the individual analysis of the two samples, the following criterion shall apply: Each of the two samples shall withstand two thirds of the minimum number of cycles under Test 6 without failure by burst or leakage. Both criteria shall be complied with;

Test 9: Extreme temperature cycle test in accordance with section 5.2.9;

By derogation from the above provisions, the test medium which flows into the sample during the test shall be tempered to the nominal temperature of the sample for the respective test stage and shall be maintained steady during the test with a ± 5 K tolerance in relation to the starting temperature of the sample and of the medium contained in the sample. Alternatively, the tolerance requirement of ± 5 K may also be complied with in a different way than by pre-tempering the test medium, e.g. by very slow pressure cycles. In this test, in concretization of the standard, a lower pressure level (minimum pressure of each cycle) of 1.0 MPa (10 bar) shall not be exceeded.

After the completion of the pressure cycle test to standard, this sample shall be subjected to failure to further pressure cycles between the upper pressure level which is at least equivalent to the test pressure (PH) and the lower pressure level which shall not exceed 10 per cent of the upper pressure level but shall not be more than 3.0 MPa (30 bar) at room temperature (RT) as described above under Test 6. For the test result in the sum of all pressure cycles on a sample, the following criterion shall apply: The sample shall withstand the minimum number of cycles under Test 6 without failure by burst or leakage;

Test 10: Fire resistance test in accordance with section 5.2.10;

The test shall be carried out if the composite tube is intended exclusively for use with a pressure relief device (PRD) and is marked in accordance with no 4.2;

Test 11: High velocity impact (bullet) test in accordance with section 5.2.11;

This test is optional. If it is carried out, it shall, by derogation from the above provision, be carried out as follows:

In the event that the targeted firing of three bullets in accordance with 5.2.11 does not result in the penetration of at least one wall of the pressure receptacle, the test shall be repeated with ammunition of test level 13 in accordance with VPAM APR 2006: "General basis for ballistic material, construction and product testing" (APR 2006, Edition, 2009-05-14) of the Vereinigung der Prüfstellen für angriffshemmende Materialien und Konstruktionen VPAM (Association of test laboratories for bullet resistant materials and constructions; see <http://www.vpam.eu/>).

In the event that even the firing of another three shots with ammunition of test level 13 does not result in the penetration of a wall or that one of the shots penetrates at least one wall but the sample does not burst, the test shall be considered satisfactory;

Note: The ammunition indicated above is a further specification of the general indication ".50 BrowningMG" or "12.7 x 99mm Nato".

Test 12: Torque test in accordance with section 5.2.12;

Test 13: Neck strength in accordance with section 5.2.13;

Test 15: Neck ring (if fitted) in accordance with section 5.2.15;

3.6.2 The following tests in accordance with section 5 of standard EN 12257:2002 may be waived:

Test 14: Cylinder stability in accordance with section 5.2.14;

3.7 Tests of the finished composite tubes

3.7.1 Batch tests

The tests shall be carried out in accordance with Annex A of standard EN 12257:2002.

By derogation from the provisions above, the test in accordance with A.4.5.1.c) shall be carried out like Test 6 (see above). For every year, the statistic analyses of the batch test results shall be presented together in the form of a comparison with the logarithmic-arithmetic mean determined within the framework of Test 6 of the type test. The sample shall meet the criteria for Test 6 of the type test.

3.7.2 Provision of the test results for comparative analyses within the framework of concepts complementary to on-site tests

In connection with periodic inspection and testing or lifetime monitoring, the manufacturer and the operator shall retain the statistics on Test 6 including the batch tests and the results of Tests 8 and 9 and shall, on request, submit them to the authority competent for on-site tests.

4 Marking

4.1 The marking shall be affixed in accordance with chapter 6.2 of RID/ADR and the IMDG Code in conjunction with EN ISO 13769 and in accordance with OrtsDruckV/TPED. In the marking in accordance with 6.2.3.9.1 in conjunction with 6.2.2.7.1 (b) of RID/ADR and the IMDG Code, instead of the mark of the technical standard the present ATR shall be indicated as follows: "ATR D 2/10".

4.2 In addition, the following specific additional information shall be indicated on a marking label which is permanently affixed to the composite tube and which may not be combined with the marking under no. 4.1:

- (a) where a composite tube is approved with a specific pressure relief device intended to prevent failure in the case of fire (see section 5.2.10 of standard EN 12257: 2002), this requirement shall be stated and the type of device shall be identified on the marking label;
- b) where the fitting torque for the valve does not correspond to the values given in standard EN 13341:2005, the manufacturer's recommendation shall be shown on the marking label;
- c) where the tube has been approved for specific uses (e.g. for underwater use), this shall be shown on the marking label;
- d) the liner material designation (e.g. "AA6061").

Note:

If composite tubes in accordance with the present ATR are carried as packages, they shall be secured in a horizontal position on loading equipment (e.g. racks, bearings) in a manner that takes into account the possible expansion of the composite tube due to temperature changes and prevents a rigid fixture while otherwise meeting the provisions of RID/ADR and the IMDG Code as regards load securing.

Berlin, 22nd July 2011

BAM FEDERAL INSTITUTE FOR MATERIALS RESEARCH AND TESTING

Department 3
Containment Systems for Dangerous Goods

Working Group 3.24
Pressure Equipment – Pressure Receptacles
and Fuel Gas Storage Systems

p.p.

p.p.

signed by Erhard

signed by Mair

Dr.-Ing. Anton Erhard
Direktor und Professor

Dr.-Ing. Georg W. Mair
Regierungsdirektor