



Recognized technical code
(Anerkanntes Technisches Regelwerk, ATR)
for the construction, equipment, test, approval, and marking
as transportable pressure equipment of composite tubes
with a non-load sharing plastics liner with a working pressure
not exceeding 500 bar and a water capacity not exceeding 450 L
(ATR D 4/10)

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 Article 1 of the 5th Ordinance of 3 August 2010 amending ordinances on the transport of dangerous goods (Federal Law Gazette I p. 1139), 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 transportable fully wrapped composite tubes with non-load sharing thermoplastic liners (ATR D 4/10) as set out below.

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 Code to the competent OTIF and UNECE² Secretariats in accordance with section 6.2.5 of RID/ADR.

In addition the Federal Institute for Materials Research and Testing promulgates the present ATR for sea transport 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 5th Ordinance amending ordinances on the transport of dangerous goods in conjunction with section 6.2.3.1 of the IMDG Code³.

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

³ IMDG Code = International Maritime Dangerous Goods Code

The present ATR may be applied to the approval of composite tubes for transport 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

- 1.1 This ATR concerns 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 and section 6.2.3 of the IMDG Code.
- 1.2 In accordance with the definition in section 1.2.1 of RID/ADR and the IMDG Code, 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 thus be designated and approved as tubes.
- 1.3 As in the table in section 6.2.4 of RID/ADR and section 6.2.2 of the IMDG Code there is no reference to a specific standard for composite tubes, a technical code to be recognized under section 6.2.5 of RID/ADR and section 6.2.3 of the IMDG Code is necessary until a harmonized standard for this purpose has been published and included in the table in section 6.2.4 of RID/ADR and in section 6.2.2 of the IMDG Code.
- 1.4 This ATR ensures a high level of safety which is at least equivalent to the safety level of cylinders under standard EN 12245:2002 which is currently referenced in the table in section 6.2.4 of RID/ADR. The present Code is based in particular on DIN EN 12245:2009 "Transportable gas cylinders – Fully wrapped composite cylinders".

2 Scope

- 2.1 The present ATR applies to the construction, equipment, test, approval and marking of composite tubes up to a maximum working pressure of 50 MPa (500 bar) and a water capacity of not more than 450 litres which have a seamless or homogeneously joined thermoplastic liner which is reinforced by a wound composite consisting of carbon and/or glass 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 – in accordance with 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, the present ATR and additionally section 6.2.3 of the IMDG Code for sea transport.

- 2.3 Of the modules possible under OrtsDruckV in conjunction with Directive 1999/36/EC (TPED), only module B may be applied in conjunction with module D or F until the provisions of section 1.8.7 of RID/ADR become applicable.
- 2.4 A conformity reassessment under OrtsDruckV in conjunction with TPED of composite tubes put 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
- 2.5 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/ADN¹⁾ 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 Specification 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 EN 12245:2009 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 or 6.2.1 and 6.2.3 of the IMDG Code as well as the provisions of EN 12245:2009 "Transportable gas cylinders - Fully wrapped composite cylinders" unless variations are permitted or stipulated in the following.

3.3 Design and manufacture of the pressure receptacles

The pressure receptacles shall be designed and manufactured in accordance with section 4 of EN 12245:2009.

3.4 Tests

3.4.1 The following tests shall be carried out in accordance with section 5 of EN 12245:2009:

- Test 1: Composite material tests in accordance with section 5.2.1.1;
- Test 2: Test of the thermoplastic liner material in accordance with 5.2.2.1 g) 1);
- Test 3: Not applicable; only relevant to load sharing liners;
- Test 4: Pressure 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;

a) Burst test with slow increase of pressure

Note: In the event that this test is carried out instead of the test under b), it becomes a mandatory part of the type test and the test under b) may be omitted.

If the type approval is based on the test under b), the test under a) shall be carried out additionally in order to provide the data basis for comparing the results of tests intended to determine long-time burst behaviour and long-time durability of type IV composite tubes on samples taken from operation.

The test shall be carried out in accordance with table A.4 on three samples at ambient conditions and, by derogation from the provisions above, the temperature on the external surface of the tube shall be maintained at between 15°C and 35°C. The filled and de-aerated samples shall be pressurised at a continuous rate of pressurization of 1 bar per minute until bursting. The pressure may also be applied in increments of 1 bar/1 minute to 5 bar/5 minutes. The deviation from the time-dependent nominal pressure shall never exceed 5 bar. The actual pressure profile shall be recorded.

b) Standard burst test

The minimum burst pressure may be established in accordance with standard EN 12245:2009. If this test is carried out for the purpose of type approval, the slow burst test under a) shall be carried out additionally on three samples to gather comparative data for subsequent tests.

The minimum burst pressure according to the standard shall be met in one of the two cases.

Test 6: Resistance to pressure cycles in accordance with section 5.2.6;

By derogation from the above provision, the tests shall be carried out at ambient conditions and on three samples. The temperature of the composite tube and of the medium shall not exceed $+50^{\circ}\text{C}^{*)}$ during the test. The cycle frequency shall only exceed 5 pressure cycles per minute if it is ensured by means of pressure measurement at the second opening of the specimen that the requirements as regards the maximum and minimum values of the pressure (pressure extremes) in the sample are complied with. The test shall be carried out on three samples and is finished in the event of failure by leakage or burst.

If the sample has withstood 48,000 load cycles (LCs) to at least test pressure $\text{PH}^{**})$ without failure, the test may be terminated. The fatigue strength established in this way shall be documented.

Irrespective of the modified test parameters, the criteria for non-limited and limited life in accordance with sub-section 5.2.6.1.2 or Table 1 in sub-section 5.2.6.2.2 of standard EN 12245:2009 shall be applied.

Assessment of the sensitivity to pressure cycling

After Test 6, the sensitivity to pressure cycles of the design type shall be assessed. This influences the further tests.

In the event that in two or more pressure cycling tests under Test 6 no failure can be observed before the test is terminated at 48.000 LCs, the design type shall be classified as “not sensitive to pressure cycles” for the further tests. In this case, all subsequent residual strengths (see Tests 6, 8, and 11) shall not be established by means of pressure cycling tests but by the slow burst test described under Test 5.

If two out of three samples fail during the pressure cycling test, the design type shall be classified as “sensitive to pressure cycles” for the following tests.

^{*)} Footnote to tests 6, 8, 11 and batch test:

After 12,000 pressure cycles (PC), the test may be continued to failure or until termination at a pressure medium and ambient temperature of at least 65°C in combination with a relative humidity of 95% (or fine spray) or in a water bath. In this case, however, the same procedure shall be followed for all relevant tests (6, 8, 11, and batch test).

^{**)} Footnote to tests 6, 8, 11 and batch test:

If Test 6 is based on the maximum developed pressure (P_{max})^{)} in accordance with sub-section 5.2.6.1.1 of EN 12245:2009, the following shall apply:*

- *The P_{max} pressure shall be applied as pressure peak to all pressure cycling tests (tests 8, 11, and batch test).*
- *The minimum number of pressure cycles to be withstood is double the number required for tests to test pressure (PH).*
- *The tests may only be terminated after 96,000 cycles.*

Test 7: Immersion in salt water in accordance with section 5.2.7. This test is necessary for tubes intended for maritime use. For all other uses, the test is optional.

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

a) Design types which are not sensitive to pressure cycles

By derogation from the above provision, for design types which are not sensitive to pressure cycles, the following shall apply:

The concluding burst tests to determine the residual strength after aging shall be carried out as described above under Test 5 a) on both samples. None of the resultant burst pressures shall be lower than 80 % of the arithmetic mean burst pressure determined previously in Test 5 a).

b) Design types sensitive to pressure cycles

By derogation from the above provision, for design types which are sensitive to pressure cycles, the following shall apply:

Instead of the concluding burst tests (Test 5), pressure cycling tests in accordance with Test 6 ^{*)} (see above) shall be carried out on both samples at room temperature. The test shall be terminated in the event of failure or may be terminated after 48,000 pressure cycles to at least test pressure PH ^{**)} . 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: Drop test as described „for cylinders over 80 litres water capacity“ in accordance with section 5.2.9.2;

Test 10: Flaw tolerance test in accordance with section 5.2.10

Test 11: Extreme temperature cycle test in accordance with sections 5.2.11.2 and 5.2.11.3;

By derogation from the above provisions, the test medium which flows into the sample during the test as described in Test 6 ^{*)} to above test pressure PH ^{**)} or the maximum developed pressure (Pmax) ^{**)} in accor-

dance with 5.2.6.1.1 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 °C tolerance in relation to the starting temperature of the sample and of the medium contained in the sample. Alternatively, the tolerance requirement of ± 5 °C may also be complied with in a different way than by pre-tempering the test medium, e.g. by very slow pressure cycles.

By derogation from the burst test to determine the residual strength in accordance with the standard, after completion of the pressure cycling test, the sample shall be pressurized to failure in accordance with the following:

a) For design types which are not sensitive to pressure cycles.

the following shall apply:

A slow burst test in accordance with the specifications of Test 5 shall be carried out. None of the resultant burst pressures shall be lower than 80 % of the arithmetic mean burst pressure determined previously in Test 5.

b) For design types sensitive to pressure cycles.

the following shall apply:

Continuation of the test with changing pressures as described in Test 6 ^{*)} to at least P_H ^{**)} or to the maximum developed pressure (P_{max}) ^{**) in accordance with 5.2.6.1.1 at ambient temperature. For the test result in the sum of all test stages on a sample, the following criterion shall apply: The sample shall withstand the minimum number of cycles stipulated in Test 6 of EN 12245:2009 without failure by burst or leakage.}

cycle test, the sample shall continue to be subjected to the point of failure to pressure cycles to P_H ^{*)}, or of the maximum developed pressure (P_{max}) ^{*)} in accordance with section 5.2.6.1.1 at room temperature. For the test result in the sum of all test stages 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 12: Fire resistance test in accordance with section 5.2.12;

Test 13: High velocity impact (bullet) test in accordance with section 5.2.13;

In the event that the targeted firing of three bullets in accordance with section 5.2.13 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 (see "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); <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 14: Permeability test in accordance with section 5.2.14;

a) Volume flow measurement

By derogation from the above provision, the test shall be carried out in a vacuum chamber using the indicated test gases. The share of the test gas in the volume flowing through the vacuum pump shall be measured. The gas analysis shall be carried out and recorded regularly. The test shall end when the record shows that at a vacuum which is kept constant the absolute volume of test gas in the evacuated measurement volume flow has not increased for at least 3 hours. The measured permeation quantity of gas shall be placed in relation to the capacity of the sample and shall be converted into a permeation rate.

b) Test with helium

As an alternative, the sample may be pressurized with helium in a helium-proof and accurately gauged chamber or similar. In this case, the increase in helium concentration within the chamber shall be measured at regular intervals. The change in the helium concentration in the known gas-filled volume of the chamber shall be evaluated as permeated gas volume and shall then be converted into a permeation rate. When there is confirmed data for transferring the permeation rate of helium to the

permeation rate of the gas to be used later, the values established with helium may be transferred to the gas-specific permeation values.

The permeation rates determined in accordance with a) or b) shall not exceed the limits indicated under Test 14 for one of the gases to be used later.

Test 15: Test of compatibility of thermoplastic liners with air or oxidising gases in accordance with section 5.2.15;

Test 16: Torque test in accordance with section 5.2.16;
By derogation from the above provision, on samples with two bosses the test shall be carried out independently on both ends if the bosses feature two different geometries or are bonded differently.

Test 17: Neck strength in accordance with section 5.2.17;

Test 19: Neck ring (if fitted) in accordance with section 5.2.19;

Additional test:

Additionally, a leakproofness test in accordance with section 8.5.15 of ISO 11119-3:2002 shall be carried out.

3.4.2 The following tests in accordance with section 5 of EN 12245:2009 may be waived:

Test 18: Cylinder stability in accordance with section 5.2.18

3.5 Testing of finished tubes

3.5.1 Batch tests

Note: This test primarily serves the purpose of improving the data basis for comparing the results of test on samples within the framework of periodic tests and inspections intended to determine long-term burst behaviour and long-term durability of type IV composite tubes. Therefore, no additional requirements are stipulated for this test.

By derogation from section 3.1.4 of EN 12245:2009, the following shall apply: If less than 200 tubes of one class/design variant are produced in one year, the batch shall be the production quantity per calendar year.

By derogation from Table A.4 of EN 12245:2009, the following shall apply for Test 6 (pressure cycling test): In case the production quantity amounts to less than 1000 pieces of one class in two years, the class shall be subjected to the pressure cycling test at least every second year independent of the number of completed batches.

The burst test shall be carried out as slow burst test in accordance with Test 5 a) of the present ATR.

If the results of the test are not satisfactory, the test may also be carried out in accordance with Test 5 b) of the present ATR. The sample shall meet the criteria for Test 5 of the type test in at least one of the cases.

For every year, the statistic analyses of batch test results of the slow burst test shall be presented together in the form of a comparison with the arithmetic mean determined within the framework of the type test.

By derogation from the provisions above, the pressure cycling test in accordance with A.4.5.1 c) shall be carried out like Test 6 (see above). The sample shall meet the criteria for Test 6 of the type test. 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 the type test. If the results of one of the two batch tests show for two years in a row that the mean values deviate from the values of the type test or the previous year by more than 5%, the manufacturer, together with the inspection body which has approved the design type and the inspection body which monitors the production, shall determine and assess the cause of the deviation.

Additionally, a leakproofness test in accordance with section 9.4.7 of ISO 11119-3:2002 shall be carried out on every finished tube.

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

In connection with periodic inspections and tests 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 11; the manufacturer shall submit the documents relevant to the respective batch of pressure receptacles to the operator; the operator shall, on request, submit the documents 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 Orts-DruckV/TPED. For the marking according to 6.2.3.9.1 in conjunction with 6.2.2.7.1 b), instead of the marking of the standard the present ATR shall be marked as follows: "ATR D 4/10".

4.2 In addition, the following information shall be indicated on a marking label which is permanently affixed to the 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 5.2.12 of EN 12245:2009), 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 EN ISO 13341:2005, the manufacturer's recommendation shall be shown on the marking label;
- c) here the composite tube is to be used for dedicated gas service or the developed pressure has been used in Test 6, the resistance to pressure cycles (see section 5.2.6 of EN 12245:2009), then the intended gas shall be stated.

5 Operating provisions

If 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 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.

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