Note by the secretariat: As part of the secretariat's efforts to reduce expenditure, this voluminous informal document No. 12 will not be distributed during the 46th GRPE session. Delegates are kindly requested to bring their copies of this document to the meeting. However, a summary of this document will be available as informal document No. 11.

PROPOSAL FOR A NEW DRAFT REGULATION

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF:

1. SPECIFIC COMPONENTS OF MOTOR VEHICLES USING COMPRESSED GASEOUS HYDROGEN;

2. VEHICLES WITH REGARD TO THE INSTALLATION OF SPECIFIC COMPONENTS FOR THE USE OF COMPRESSED GASEOUS HYDROGEN;

Prepared by:
UN ECE WP.29 GRPE Informal Group “Hydrogen/Fuel Cell Vehicles” based on proposals developed by the Partners of the European Integrated Hydrogen Project – Phase II (EIHP2).

Notes:
1. For editing purposes the following colour codes have been adopted:
   i) Green highlighting identifies reference to standards, etc.
   ii) Yellow highlighting identifies references to other parts of this document.

2. A number of key words or phrases have been defined and are indicated in the text by Capitalised Italic Font. As these definitions are crucial to the correct interpretation of this document it is strongly recommended that they remain highlighted in the final Regulation.
CONTENTS

REGULATION

Page No.
1 Scope
2 Definitions, container types, pressure classifications and service conditions

Part I  SPECIFIC COMPONENTS OF MOTOR VEHICLES USING COMPRESSED GASEOUS HYDROGEN
3 Application for approval
4 Markings
5 Approval
6 Specifications for hydrogen components
7 Modification of a specific component and extension of approval
8 Conformity of production
9 Penalties for non-conformity of production
10 Production definitely discontinued
11 Names and addresses of Technical Services responsible for conducting approval tests and of Administrative Departments

Part II  VEHICLES WITH REGARD TO THE INSTALLATION OF SPECIFIC COMPONENTS FOR THE USE OF COMPRESSED GASEOUS HYDROGEN
12 Application for approval
13 Approval
14 Requirements for the installation of specific components for the use of compressed gaseous hydrogen within motor vehicles
15 Modification of a vehicle type or hydrogen system and extension of approval
16 Conformity of production
17 Penalties for non-conformity of production
18 Production definitely discontinued
19 Names and addresses of Technical Services responsible for conducting approval tests and of Administrative Departments
ANNEXES

1 Essential characteristics of specific components
2 Essential characteristics of the vehicle, hydrogen related propulsion system and other hydrogen related systems
3 Arrangement of the specific component approval marks
4 Communication concerning the approval, or refusal, or extension, or withdrawal, or production definitely discontinued of a specific component pursuant to Regulation No. [X]
5 Arrangements of approval marks for a vehicle type with regard to the installation of a hydrogen system
6 Communication concerning the approval, or refusal, or extension, or withdrawal, or production definitely discontinued of a vehicle type with regard to the installation of a hydrogen system pursuant to Regulation No. [XX]
7 Requirements and approval test procedures for containers
8 Requirements and approval test procedures for specific components other than containers
9 Special requirements to be applied to the safety aspects of complex electronic vehicle control systems
10 Provisions regarding hydrogen identification marks for public service vehicles
1 SCOPE

This Regulation applies to:

1.1 Compressed gaseous hydrogen systems for motor vehicles in which the hydrogen is stored in its gaseous phase under pressure and essentially at ambient temperature, including the complete Hydrogen System, i.e. excluding the Propulsion System (internal combustion engine or fuel cell system) or any auxiliary power unit.

1.2 Specific Components of motor vehicles of categories M*1 and N*1 using compressed gaseous hydrogen (Part I of this Regulation).

1.3 Vehicles of categories M*1 and N*1 with regard to the installation of Specific Components for the use of compressed gaseous hydrogen (Part II of this Regulation).

Note: *1 As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3), annex 7 (TRANS/WP.29/78/Rev.1/Amend.2)

2 DEFINITIONS, CONTAINER TYPES, PRESSURE CLASSIFICATIONS AND SERVICE CONDITIONS

2.1 DEFINITIONS

For the purpose of this Regulation and the accompanying Annexes the following definitions shall apply and are indicated in the text by capitalised italic words, e.g. Valve:

2.1.1 "Approval Of A Vehicle Type": Approval of a type of vehicle with regard to its Hydrogen System installed as original equipment.

2.1.2 "Automatic Valve": A valve that is not operated manually. A Non-return Valve is not an Automatic Valve.

2.1.3 "Auto-frettage": A pressure application procedure used in manufacturing Composite Containers with metal Liners, which strains the Liner past its yield point sufficiently to cause permanent plastic deformation, which results in the Liner having compressive stresses and the fibres having tensile stresses at zero internal pressure.

2.1.4 "Auto-frettage Pressure": The pressure within the Over-wrapped Container at which the required distribution of stresses between the Liner and the Over-wrap is established.

2.1.5 "Batch": A production quantity of successively produced Finished Containers having the same nominal dimensions, design, specified materials of construction, process of manufacture, equipment for manufacture and, where appropriate, conditions of time, temperature and atmosphere during heat treatment.

2.1.6 "Boundary of Functional Operation": Defines the boundaries of the external physical limits within which a system is able to maintain control.

2.1.7 "Burst Pressure": The Pressure at which the Container ruptures.
2.1.8 "CGH_2": Compressed gaseous hydrogen.

2.1.9 "Complex Electronic Vehicle Control Systems": Those Electronic Control Systems which are subject to a hierarchy of control in which one electronically controlled function may be over-ridden by a higher level Electronic Control System/function. In this case, the function that is over-ridden becomes part of the complex system.

2.1.10 “Composite Container”: A Container constructed of more than one material.

2.1.11 "Container": Any vessel used for the storage of compressed gaseous hydrogen within the temperature limits specified in this Regulation, excluding any other Hydrogen Components which may be attached to or fitted inside the Container.

2.1.12 “Container Assembly”: Two or more Containers with integral interconnecting fuel lines protectively encased inside a housing shell.

2.1.13 “Duty Cycle”: One start up and shut down cycle of the Hydrogen Conversion System(s).

2.1.14 “Electronic Control System”: A combination of Units, designed to co-operate in the production of the stated vehicle control function by electronic data processing. Such systems, often controlled by software, are built from discrete functional components such as sensors, electronic control units and actuators and connected by Transmission Links. They may include mechanical, electro-pneumatic or electro-hydraulic elements.

2.1.15 “Excess Flow System”: A system that shuts off the flow without manual intervention in the event of a pipe rupture or similar severe leakage.

2.1.16 “Filling Cycle”: A pressure increase of more than 25% of the Working Pressure of the Container due to an external source of hydrogen.

2.1.17 “Finished Container”: A Container that is typical of normal production, complete with identification marks and external coating including integral insulation specified by the Manufacturer, but free from non-integral insulation or protection.

2.1.18 “First Pressure Regulator”: The Pressure Regulator having the Container pressure as its inlet pressure.

2.1.19 “Fitting”: A non-permanent connector used in a piping, tubing or hose system.

2.1.20 "Flexible Fuel Line": A flexible tubing or hose of any length through which hydrogen flows.

2.1.21 "Fuel Supply Line": The line that supplies the Hydrogen Conversion System(s) with hydrogen.

2.1.22 “Ful Wrap”: Over-wrap with the filaments wound around the Liner both in the circumferential and longitudinal directions of the Container.
2.1.23 “Hoop Wrap”: Over-wrap with the filaments wound in a substantially circumferential pattern over the cylindrical portion of the Liner, so that the filaments do not carry any significant load in the longitudinal direction of the Container.

2.1.24 "Hydrogen Component": A component that is in direct contact with hydrogen or which forms part of a system installed because of the use of hydrogen. A Hydrogen Component can consist of a combination of metallic and non-metallic parts/subcomponents.

2.1.25 "Hydrogen Conversion System": Any system designed for the conversion of hydrogen into electrical, mechanical or thermal energy, and includes, for example, the Propulsion System(s) or auxiliary power unit(s).

2.1.26 “Hydrogen Filter”: A filter used to separate oil, water and dirt from hydrogen.

2.1.27 “Hydrogen Sensor”: A sensor used to detect hydrogen in air.

2.1.28 "Hydrogen System": An assembly of Hydrogen Components and connecting parts fitted on motor vehicles using hydrogen, excluding the Hydrogen Conversion System(s). The boundary between the Hydrogen System and the Hydrogen Conversion System(s) shall be defined by the vehicle manufacturer, but as a minimum requirement it shall be defined as the point(s) at which the Nominal Working Pressure is higher than the:

i) Maximum operating Pressure of fuel cell system(s),

ii) The inlet Pressure of the gas mixer (carburettor or injector(s)) for internal combustion engines or other combustion devices.

2.1.29 “Leak Test Gas”: Hydrogen, helium or an inert gas mixture containing at least 5% hydrogen or 10% helium or a demonstrated detectable amount of helium or hydrogen gas.

2.1.30 “Liner”: A Container that is used as a gas tight, inner shell, on which reinforcing fibres are filament wound to reach the necessary strength. Liners may be designed to share the load with the reinforcement, or not to carry any part of the load.

2.1.31 "Manual Valve": A manually operated valve.

2.1.32 “Manufacturer”: The person or organisation responsible for the design, manufacturing, testing and conformity of production of a Hydrogen Component.

2.1.33 “Maximum Allowable Working Pressure (MAWP)”: The maximum pressure to which a component downstream of a Pressure Regulator is subjected.

2.1.34 “Multifunctional Component”: Specific Components combined or fitted together and which may include Hydrogen Components.

2.1.35 “Nm³” or “Ncm³” (normal cubic metre or centimetre): A volume of dry gas that occupies a volume of 1 m³ or 1 cm³ at a temperature of 273.15 K (0 °C) and an absolute pressure of 101.325 kPa (1 atm).
2.1.36 "Nominal Working Pressure": The pressure level at which a component typically operates. For Containers it is the settled pressure at a uniform temperature of 288K (15°C) for a full Container.

2.1.37 "Non-return Valve": A valve that allows hydrogen to flow in only one direction.

2.1.38 "Over-wrap": Resin impregnated continuous filaments used as reinforcement around a Liner.

2.1.39 "Pressure": Gauge pressure measured in MPa against atmospheric pressure, unless otherwise stated.

2.1.40 "Pressure Regulator": A device used to control the delivery Pressure of gaseous fuel to the Hydrogen Conversion System.

2.1.41 "Pressure Relief Device": A non-reclosing thermally activated device that prevents a Container from bursting due to fire effects.

2.1.42 "Pressure Relief Valve": A reclosing pressure activated device that prevents a Hydrogen Component from bursting due to excessive pressure.

2.1.43 "Propulsion System": The internal combustion engine or fuel cell system used to propel the vehicle.

2.1.44 "Range of Control": Refers to an output variable and defines the range over which the system is likely to exercise control.

2.1.45 "Receptacle": A device fitted in the vehicle used to permit refilling of the Container(s), i.e. a filling unit.

2.1.46 "Removable Storage System": A removable system within a vehicle that houses and protects one or more Containers or a Container Assembly and includes all Class 0 Hydrogen Components used in the Hydrogen System.

2.1.47 "Removable Storage System Connector": The hydrogen connection device between a Removable Storage System and the section of the Hydrogen System permanently installed in the vehicle. A Removable Storage System Connector consists of parts mounted on the Removable Storage System and on the vehicle.

2.1.48 "Rigid Fuel Line": Tubing that has not been designed to flex in normal operation and through which hydrogen flows.

2.1.49 "Safety Concept": Measures designed into the system to ensure safe operation even in the event of a failure or random faults.

2.1.50 "Safety Device": A device intended to ensure safe operation.

2.1.51 "Safety Instrumented Systems": Process control systems that prevent an impermissible fault range from being reached by an automatic intervention in the process.

2.1.52 "Service Life": The life in years during which the Containers may safely be used in accordance with the service conditions.
2.1.53 "Specific Component": A Hydrogen Component that is subjected to type approval in accordance with this Regulation.

2.1.54 "Transmission Links": The means used for interconnecting distributed Units for the purpose of conveying signals, operating data or an energy supply. This equipment is generally electrical but can be mechanical, pneumatic or hydraulic.

2.1.55 "Units": The smallest divisions of system components that will be considered, as these combinations of components will be treated as single entities for purposes of identification, analysis or replacement.

2.1.56 “Usage Monitoring And Control System”: A system that counts the Filling Cycles and prevents further use of the vehicle when a predetermined number of Filling Cycles is exceeded.

2.1.57 "Vehicle Type": A vehicle fitted with Specific Components for the use of hydrogen that does not differ with respect to the following conditions:
   i) The Manufacturer(s),
   ii) The installation of the Hydrogen Components,
   iii) Type(s) of Specific Components.

2.2 CONTAINER TYPES

A Container shall be classified into the following types according to the type of construction:

Type 1  Seamless metallic Container.

Type 2  Hoop Wrapped Container with a seamless metallic Liner.

Type 3  Fully Wrapped Container with a seamless or welded metallic Liner.

Type 4  Fully Wrapped Container with a non-metallic Liner.

2.3 PRESSURE CLASSIFICATIONS

Hydrogen Components shall be classified with regard to their Nominal Working Pressure and function as defined below:

Class 0  High-pressure components/systems including fuel lines and Fittings containing hydrogen at a Nominal Working Pressure greater than 3.0 MPa.

Class 1  Medium-pressure components/systems including fuel lines and Fittings containing hydrogen at a Nominal Working Pressure greater than 0.45 MPa and up to and including 3.0 MPa.
Class 2 Low-pressure components/systems including fuel lines and Fittings containing hydrogen at a Nominal Working Pressure up to and including 0.45 MPa.

2.4 SERVICE CONDITIONS

Unless indicated otherwise the following service conditions shall apply throughout this Regulation and its Annexes:

2.4.1 Service Life

The Service Life of Hydrogen Components shall be specified by the vehicle manufacturer and may vary with different applications, however, it shall not exceed 20 years.

2.4.2 Working Pressure

The vehicle manufacturer shall specify the Nominal Working Pressure(s) of the Hydrogen System. For the components downstream of the First Pressure Regulator, the MAWP(s) shall also be specified.

The MAWP(s) shall be equal to or shall exceed the set pressure of the overpressure protection specified in Paragraph 14.1.18 of this Regulation.

2.4.3 External Surfaces

The effects on external surfaces of the Hydrogen Components in their installed position shall be considered in relation to the following:
   i) Water, either by intermittent immersion or road spray,
   ii) Salt, due to the operation of the vehicle near the ocean or where ice melting salt is used,
   iii) Ultra-violet radiation from sunlight,
   iv) Impact of gravel,
   v) Solvents, acids and alkalis, fertilisers,
   vi) Automotive fluids, including gasoline, hydraulic fluids, battery acid, glycol and oils,
   vii) Exhaust gases.

2.4.4 Gas Composition

Compressed hydrogen gas shall comply with, or be of greater purity than, the Type 1, Grade A gas composition specified in ISO 14687:1999/Cor1:2001 Hydrogen Fuel – Product Specification.

2.4.5 Temperatures

2.4.5.1 Material Temperatures

The normal operating temperature range for materials used in Hydrogen Components shall be -40°C to +85°C except for:
i) *Hydrogen Components* situated in an internal combustion engine compartment for which the temperature range shall be -40°C to +105°C,

ii) *Hydrogen Components* either installed on an internal combustion engine, or directly exposed to the operating temperature of an internal combustion engine, for which the temperature range shall be -40°C to +120°C.

2.4.5.2 Gas Temperatures

The average gas temperature shall be between -40°C to +85°C in normal conditions including filling or discharging.

2.4.6 *Filling Cycles*

This Paragraph is only applicable to Class 0 *Hydrogen Components*.

2.4.6.1 General

The number of *Filling Cycles* for the *Hydrogen Components* approved in accordance with this Regulation shall be 5000 cycles except as permitted in Paragraphs 2.4.6.2 and 2.4.6.3 of this Regulation.

2.4.6.2 Extended Number of *Filling Cycles*

The vehicle manufacturer may specify an extended number of *Filling Cycles* for the *Hydrogen Components* based on the design lifetime mileage of the vehicle and range with maximum fuel capacity, but shall not be less than 5000 cycles, i.e.:

Design lifetime mileage of the vehicle, \(L\)

Range with maximum fuel capacity, \(R\)

Number of *Filling Cycles* = \(L/R\) but not less than 5000

2.4.6.3 Reduced Number of *Filling Cycles*

Provided that a *Usage Monitoring And Control System* is installed as part of the *Hydrogen System*, the number of *Filling Cycles* for *Hydrogen Components* approved in accordance with this Regulation shall be specified by the vehicle manufacturer and may be less than 5000 cycles and may vary with different applications based on the design lifetime mileage of the vehicle and range with maximum fuel capacity. The *Usage Monitoring And Control System* shall prevent any further use of the vehicle when the specified number of *Filling Cycles* is exceeded, until the *Hydrogen Components* that have exceeded that value are replaced with new *Hydrogen Components*.

The safety concept of the *Usage Monitoring And Control System* shall be approved in accordance with Annex 9 of this Regulation.

2.4.7 *Duty Cycles*
2.4.7.1 General

The number of Duty Cycles for Hydrogen Components approved in accordance with this Regulation shall be 50,000 cycles except as permitted in Paragraph 2.4.7.2 of this Regulation.

2.4.7.2 Reduced or Extended Number of Duty Cycles

The vehicle manufacturer may specify a reduced or extended number of Duty Cycles for each Hydrogen Component based on the design lifetime mileage of the vehicle divided by 20, i.e.:

Design lifetime mileage of the vehicle, \( L \text{ (km)} \)

Number of Duty Cycles = \( L \text{ (km)} / 20 \).
PART I

SPECIFIC COMPONENTS OF
MOTOR VEHICLES USING COMPRESSED GASEOUS HYDROGEN

3 APPLICATION FOR APPROVAL

3.1 The application for approval of a Specific Component or Multifunctional Component shall be submitted by the holder of the trade name or mark or by his duly accredited representative.

3.2 The application for type approval shall be accompanied by the following documents in triplicate:

i) A detailed description of the type of the Specific Component according to Annex 1 to this Regulation,

ii) A drawing of the Specific Component sufficiently detailed and on an appropriate scale with a list of parts including material data and intended operating mode,

iii) Verification of compliance with the specifications prescribed in Paragraph 6 of this Regulation.

3.3 At the request of the Technical Service responsible for conducting approval tests, two samples of the Specific Component shall be provided unless otherwise stated in this Regulation.

3.4 The Competent Authority shall verify the existence of satisfactory arrangements for ensuring effective control of conformity of production before type approval is granted.

4 MARKINGS

4.1 The samples of the Specific Component submitted for approval shall bear the trade name or mark of the Manufacturer and the type; and in addition for Flexible Fuel Lines the manufacturing month and year. The marking shall be legible and indelible.

4.2 All Specific Components shall have a space large enough to accommodate the approval mark. This space shall be shown on the drawings referred to in Paragraph 3.2 ii) of this Regulation.

5 APPROVAL

5.1 If the Specific Component samples submitted for approval meet the relevant requirements of Paragraph 6 of this Regulation, approval of the type of Specific Component shall be granted.

5.2 An Approval number shall be assigned to each type of Specific Component type approved. Its first two digits shall indicate the series of amendments to this Regulation incorporating the most recent major technical amendments made at the time of granting the approval (00 for the Regulation in its original form). The same Contracting Party shall not assign the allocated code to another type of Specific Component.
5.3 Notice of approval or of refusal or of extension of approval of a Specific Component in accordance with this Regulation shall be communicated to the Parties to the Agreement applying this Regulation by the Administrative Department by means of a form conforming to the model in Annex 4 to this Regulation.

5.4 In addition to the markings prescribed in Paragraph 4.1 of this Regulation and for Containers in Annex 7 to this Regulation, there shall be affixed conspicuously in the space referred to in Paragraph 4.2 of this Regulation, to all Specific Components conforming to a type approved under this Regulation, an international approval mark consisting of:
   i) A circle surrounding the letter "E" followed by the distinguishing number of the country that has granted approval (see Note *1 below).
   ii) The number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in i) above. This approval number consists of the Specific Component type approval number that appears on the certificate completed for this type (see Paragraph 5.2 of this Regulation and Annex 4 to this Regulation) preceded by 2 figures indicating the sequence of the latest series of amendments to this Regulation.

5.5 The approval mark shall be clearly legible and indelible.

5.6 Annex 3 to this Regulation gives an example of the arrangement of the aforesaid approval mark.

Note *1:
1 for Germany, 2 for France, 3 for Italy, 4 for Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for the Russian Federation, 23 for Greece, 24 Ireland, 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32-36 (vacant), 37 for Turkey, 38-39 (vacant) and 40 for the former Yugoslav Republic of Macedonia, 43 Japan.

Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.
6 SPECIFICATIONS FOR HYDROGEN COMPONENTS

6.1 GENERAL PROVISIONS

6.1.1 The Hydrogen Components shall function in a correct and safe way as specified in this Regulation. They shall remain functional under the mechanical, thermal and chemical service conditions specified in Paragraph 2.4 of this Regulation, and shall also reliably withstand these conditions without leaking or visibly deforming.

6.1.2 The materials of components which are in contact with hydrogen shall be compatible with hydrogen and expected additives and production contaminants.

6.1.3 Material compatibility with the service conditions defined in Paragraph 2.4 of this Regulation shall be demonstrated either by the material tests in Annexes 7 and 8 to this Regulation, or by a previously approved test certificate.

6.1.4 If a test method is used other than those referred to in this Regulation its equivalence shall be demonstrated.

6.1.5 All Hydrogen Components that are designed for uni-directional flow shall have the flow direction clearly indicated.

6.1.6 Specific Components shall be type approved in accordance with the relevant electromagnetic compatibility requirements of ECE Regulation No 10, 02 series of amendments, or equivalent.

6.1.7 Specific Components where used in the Hydrogen System include:
   i) Class 0 components. These components where used may include:
      Automatic Valve,
      Container,
      Container Assembly,
      Fittings,
      Flexible Fuel Line,
      Heat exchanger,
      Hydrogen Filter,
      Manual Valve,
      Non-return Valve,
      Pressure Regulator,
      Pressure Relief Device,
      Pressure Relief Valve,
      Receptacle.
      Removable Storage System Connector,
      Sensors (pressure or temperature or hydrogen or flow sensors) if used as a Safety Device.
   ii) The Usage Monitoring And Control System referred to in Paragraph 2.4.6.3 of this Regulation,
   iii) The vehicle interface system defined in Paragraph 14.3.9 of this Regulation,
   iv) The Excess Flow System defined in Paragraph 14.1.16 of this Regulation,
v) The overpressure protection system, e.g. Pressure Relief Valve, defined in Paragraph 14.1.18 of this Regulation,
vi) The heat exchanger failure detection system defined in Paragraph 14.1.19 of this Regulation

6.1.8 The functions of Specific Components may be combined or fitted together with other Specific Components or Hydrogen Components as a Multifunctional Component, but for the purposes of this Regulation will be classified as a Specific Component. A Multifunctional Component shall be type approved in accordance with the requirements for the Specific Components that it combines.

6.1.9 Welded fittings or connections shall be described in a production process for each individual type of welding. Welded connections upstream of the First Pressure Regulator shall be hydraulically pressure tested to 3 times Nominal Working Pressure without rupturing. Welded connections downstream of the First Pressure Regulator shall be hydraulically pressure tested to 3 times Maximum Allowable Working Pressure without rupturing.

6.1.10 Unless indicated otherwise, the requirements of this Regulation and its Annexes shall take precedence over any standards referred to herein.

6.1.11 The documentation and test reports shall be sufficiently detailed to enable an independent third party test facility to reproduce the appropriate type approval tests and test results.

6.2 PROVISIONS REGARDING CONTAINERS

6.2.1 Containers of Types 1 to 4 as defined in Paragraph 2.2 of this Regulation, shall be type approved pursuant to the provisions laid down in Annex 7 to this Regulation.

6.2.2 The shape of a Container is free provided that it fulfils all the appropriate provisions laid down in Annex 7 to this Regulation.

6.2.3 Container Assembly

6.2.3.1 A Container Assembly shall be approved as one Container if both the Container Assembly and constituent Containers are approved in accordance with the provisions laid down in Annex 7 to this Regulation.

6.2.3.2 Alternatively a Container Assembly shall be approved as one Container if the Container Assembly fulfils the provisions laid down in Annex 7 to this Regulation. The constituent Containers need not fulfil all the provisions laid down in Annex 7 to this Regulation provided that the Container Assembly can fulfil all the appropriate provisions.

6.2.3.3 For all types of Container, the Container Assembly shall fulfil the requirements of Paragraphs B12, B18 and B19 of Annex 7 to this Regulation. The Container Assembly shall be encased inside a protective housing shell.
6.2.3.4 A maximum of 4 Containers per Container Assembly shall be permitted.

6.2.3.5 Flexible Fuel Lines shall not be used as integral interconnecting fuel lines in a Container Assembly.

6.3 PROVISIONS REGARDING SPECIFIC COMPONENTS OTHER THAN CONTAINERS OR CONTAINER ASSEMBLIES

6.3.1 Specific Components other than Containers or Container Assemblies shall be type approved according to Annex 8 to this Regulation.

6.3.2 Unless otherwise stated in this Regulation, the parts of a Removable Storage System Connector mounted on the Removable Storage System and on the vehicle shall be treated as separate components.

6.4 PROVISIONS REGARDING RIGID FUEL LINES

Rigid Fuel Lines upstream of the First Pressure Regulator shall be bent through 180 degrees at the minimum bending radius specified by the Manufacturer and shall then be hydraulically pressure tested to 3 times Nominal Working Pressure without rupturing. Rigid Fuel Lines, downstream of the First Pressure Regulator shall be bent through 180 degrees at the minimum bending radius specified by the Manufacturer and shall then be hydraulically pressure tested to 3 times MAWP without rupturing.

6.5 PROVISIONS REGARDING ELECTRICAL COMPONENTS

Electrical components of equipment in contact with hydrogen shall:

i) Be insulated in such a manner that no current passes through hydrogen containing parts,

ii) Have the electrical system of the device insulated from the:

a) Body of the component,

b) Container or Container Assembly.

7 MODIFICATIONS OF A TYPE OF A SPECIFIC COMPONENT AND EXTENSION OF APPROVAL

7.1 Every modification of a Specific Component shall be notified to the Administrative Department that granted the type approval. The Administrative Department may then either:

i) Consider that the modifications made are unlikely to have an appreciably adverse effect, and that the component still meets the requirements of this Regulation;

or

ii) Require a further report from the Technical Service responsible for carrying out the tests. Modifications of Containers require approval testing as specified in Paragraph A7 of Annex 7 to this Regulation.

7.2 Notice of confirmation, extension or refusal of approval shall be communicated by the procedure specified in Paragraph 5.3 of this Regulation to the Parties to the Agreement that apply this Regulation.
7.3 The competent authority issuing the extension of approval shall assign a series number to each communication form (specified in Paragraph 5.3 of this Regulation) issued for such an extension, and shall inform the other Parties to the Agreement with a form conforming to the model in Annex 4 to this Regulation.

8 CONFORMITY OF PRODUCTION

The conformity of production procedures shall comply with those set out in the Agreement, Appendix 2 (E/ECE/324-E/ECE/TRANS/505/Rev.2) and with the following requirements:

i) A Hydrogen Component type approved according to this Regulation shall be manufactured so as to conform to the type approved by meeting the requirements specified in Paragraph 6 of this Regulation.

ii) The approval authority that has granted type approval may at any time verify the conformity control methods applied in each production facility. The normal frequency of these verifications shall be once every two years.

9 PENALTIES FOR NON-CONFORMITY OF PRODUCTION

9.1 The approval granted in respect of a Specific Component in accordance with this Regulation may be withdrawn if the requirements laid down in Paragraph 8 of this Regulation are not complied with.

9.2 If a Contracting Party to the Agreement that applies this Regulation withdraws an approval it has previously granted, it shall immediately notify the other Contracting Parties applying this Regulation by means of a communication form conforming to the model in Annex 4 to this Regulation.

10 PRODUCTION DEFINITELY DISCONTINUED

If the holder of the approval for a Specific Component type approved in accordance with this Regulation, permanently ceases to manufacture the component, he shall immediately inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform the other Parties to the Agreement applying this Regulation of that communication, by means of a communication form conforming to the model in Annex 4 to this Regulation.

11 NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the Technical Services responsible for conducting approval tests and of the Administrative Departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval issued in other countries, are to be sent.
PART II

VEHICLES WITH REGARD TO THE INSTALLATION OF SPECIFIC COMPONENTS FOR THE USE OF COMPRESSED GASEOUS HYDROGEN

12 APPLICATION FOR APPROVAL

12.1 The application for Approval Of A Vehicle Type with regard to the installation of Specific Components for the use of compressed gaseous hydrogen shall be submitted by the vehicle manufacturer or by his duly accredited representative.

12.2 The application shall be accompanied by a description of the vehicle comprising all the relevant particulars referred to in Annex 2 to this Regulation in triplicate.

12.3 A vehicle, representative of the Vehicle Type to be type approved, shall be submitted to the Technical Service conducting the approval tests.

12.4 The competent authority shall verify the existence of satisfactory arrangements for ensuring effective control of conformity of production before type approval is granted.

13 APPROVAL

13.1 If the vehicle submitted for type approval pursuant to this Regulation is fitted with Specific Components in accordance with Part I of this Regulation and meets the requirements of Part II of this Regulation, approval of that Vehicle Type shall be granted.

13.2 An approval number shall be assigned to each Vehicle Type approved. Its first two digits shall indicate the series of amendments to this Regulation incorporating the most recent major technical amendments made at the time of granting the approval (00 for the Regulation in its original form). The same Contracting Party shall not assign the approval number to another Vehicle Type.

13.3 Notice of approval or of refusal or of extension of Approval Of A Vehicle Type in accordance with this Regulation shall be communicated to the Parties to the Agreement applying this Regulation by means of a form conforming to the model in Annex 6 to this Regulation.

13.4 There shall be affixed to every Vehicle Type approved under this Regulation, conspicuously and in a readily accessible space specified on the approval form referred to in Paragraph 13.3 of this Regulation, an international approval mark consisting of:

i) A circle surrounding the letter "E" followed by the distinguishing number of the country that has granted approval (see Note *1 below).

ii) The number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in Paragraph i) above. This approval number consists of the Vehicle Type approval number that appears on the certificate completed for this type (see Paragraphs 13.2 and 13.3 of this Regulation and Annex 6 to this Regulation).
13.5 If the vehicle conforms to a Vehicle Type approved under one or more other Regulations annexed to the Agreement in the country which has granted approval under this Regulation, the symbol prescribed in Paragraph 13.4 i) of this Regulation need not to be repeated. In such a case, the Regulation and approval numbers and the additional symbols of all the Regulations under which approval has been granted in the country that has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in Paragraph 13.4 i) of this Regulation.

13.6 The type approval mark shall be clearly legible and be indelible.

13.7 The type approval mark shall be placed close to or on the statutory plate of the vehicle.

13.8 Annex 5 to this Regulation gives examples of the arrangement of the type approval mark referred to above.

Note *1:
1 for Germany, 2 for France, 3 for Italy, 4 for Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for the Russian Federation, 23 for Greece, 24 Ireland, 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32-36 (vacant), 37 for Turkey, 38-39 (vacant) and 40 for the former Yugoslav Republic of Macedonia, 43 Japan.
Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.
14 REQUIREMENTS FOR THE INSTALLATION OF SPECIFIC COMPONENTS FOR 
THE USE OF COMPRESSED GASEOUS HYDROGEN WITHIN MOTOR VEHICLES

14.1 GENERAL

14.1.1 The *Hydrogen System* of a vehicle shall function in a safe and proper 
manner. It shall reliably withstand the chemical, electrical, mechanical and 
thermal service conditions specified in Paragraph 2.4 of this Regulation 
without leaking or visibly deforming. The number of *Hydrogen Components*, 
connections and the length of lines shall be kept to the minimum 
compatible with safety and the correct functioning of the *Hydrogen System*.

14.1.2 *Specific Components* of the *Hydrogen System* shall be type approved 
pursuant to Part I of this Regulation.

14.1.3 The materials used in the *Hydrogen System* shall be compatible with 
gaseous hydrogen and expected additives and production contaminants, 
and expected temperatures and pressures.

14.1.4 The temperature range shall be in accordance with Paragraph 2.4.5 of this 
Regulation.

14.1.5 No component of the *Hydrogen System*, including any protective materials 
that form part of such components, shall project beyond the outline of the 
vehicle or protective structure. This shall not apply if a *Hydrogen Component* is adequately protected and no part of the *Hydrogen Component* is located outside this protective structure.

14.1.6 The *Hydrogen System* shall be installed such that it is protected against 
damage so far as is reasonably practical, such as damage due to moving 
vehicle components, collision, grit or due to the loading or unloading of the 
vehicle or the shifting of loads. This Paragraph also applies to *Pressure Relief Device* vents.

14.1.7 No component of the *Hydrogen System* shall be located near the exhaust 
of an internal combustion engine or other heat source, unless such 
components are adequately shielded against heat.

14.1.8 The ventilating or heating system for a passenger compartment and places 
where leakage or accumulation of hydrogen is possible shall be kept apart 
so that hydrogen is not drawn into the vehicle.

14.1.9 Reasonable precautions shall be taken to avoid failure of other circuits 
affecting the *Hydrogen System*.

14.1.10 The *Hydrogen System* shall be pressurised to *Nominal Working Pressure* 
using *Leak Test Gas* and tested for leakage with a surface active agent 
without formation of bubbles for three minutes, or by using a demonstrated 
equivalent method The permitted leakage rate is applicable to tests with 
100% hydrogen only. Permitted leakage rates for other gases or gas 
mixtures shall be converted to an equivalent leakage rate to that for 100% 
hydrogen.
14.1.11 In the event of hydrogen leakage or venting, hydrogen shall not be allowed to accumulate in enclosed or semi-enclosed spaces.

14.1.12 *Hydrogen Components* that could leak hydrogen and that are mounted within the passenger or luggage compartment or other non-ventilated compartment shall be enclosed by a gas tight housing in accordance with Paragraph 14.10 of this Regulation or by an equivalent solution.

14.1.13 The location of the *Container or Container Assembly* shall take into account possible sources of corrosion, e.g. due to road de-icing salt, leakage of acid batteries.

14.1.14 A minimum overpressure of 0.2 MPa shall be maintained in the *Container or Container Assembly* at ambient temperature.

14.1.15 All *Pressure Relief Devices*, other safety components and vent lines shall be protected against unauthorised interference so far as is reasonably practicable.

14.1.16 An *Excess Flow System* shall be part of the *Hydrogen System*.

14.1.17 *Automatic Valves* shall fail to the safest mode of operation for the particular application, i.e. fail-safe.

14.1.18 The *Hydrogen System* downstream of a *Pressure Regulator* shall be protected against overpressure due to the possible failure of the *Pressure Regulator*. The set pressure of a *Pressure Relief Valve* shall be:
   i) Lower than or equal to the MAWP for the appropriate section of the *Hydrogen System*,
   ii) Higher than or equal to 1.3 times the *Nominal Working Pressure* for the appropriate section of the *Hydrogen System*.

14.1.19 A system shall be provided to detect failure in either circuit of a heat exchanger and prevent hydrogen from entering the other circuit(s), if the interface(s) is not able to withstand loss of pressure in either circuit.

### 14.2 INSTALLATION OF A CONTAINER ON-BOARD A VEHICLE

14.2.1 A *Container or Container Assembly* shall be permanently installed on-board the vehicle and shall only be removed for maintenance. A *Container or Container Assembly* shall not be installed in the internal combustion engine compartment.

14.2.2 Notwithstanding the provisions of Paragraph 14.2.1 of this Regulation, a *Removable Storage System* may be removed from the vehicle for refilling. The *Container(s) or Container Assembly* and the *Hydrogen Components* forming the *Removable Storage System* shall be permanently installed within the *Removable Storage System*.

14.2.3 A *Container or Container Assembly* can fulfil integrated functions of the vehicle. A *Container or Container Assembly* shall be designed to fulfil the integrated function requirements plus the *Container* requirements.
14.2.4 A Container or Container Assembly including Safety Devices shall be mounted and fixed so that the following accelerations can be absorbed (without degrading the function of Safety Devices) when the Container or Container Assembly is full. No uncontrolled release of hydrogen is permitted.

Vehicles of categories M1 and N1:
   i) +/-20 g in the direction of travel
   ii) +/-8 g horizontally perpendicular to the direction of travel

Vehicles of categories M2 and N2:
   i) +/-10 g in the direction of travel
   ii) +/-5 g horizontally perpendicular to the direction of travel

Vehicles of categories M3 and N3:
   i) +/-6.6 g in the direction of travel
   ii) +/-5 g horizontally perpendicular to the direction of travel

A calculation method can be used instead of practical testing if its equivalence can be demonstrated by the applicant for approval to the satisfaction of the Technical Service.

14.2.5 The provision of Paragraph 14.2.4 shall not apply if the vehicle is approved according to ECE R 94 and ECE R 95, nonetheless, no uncontrolled release of hydrogen is permitted.

14.2.6 Pressure Relief Device(s) in accordance with Paragraph 14.5 of this Regulation shall form the fire protection system for a Container or Container Assembly to prevent rupture. Thermal insulation or other protective measures shall not influence the response and performance of the Pressure Relief Device(s).

14.2.7 A Container or Container Assembly with non-metallic Liner(s) shall not be installed inside the vehicle unless integrated into a system which ensures that permeated hydrogen will be vented outside the vehicle, e.g. it is installed inside a gas tight housing in accordance with Paragraph 14.10 of this Regulation.

14.3 REMOVABLE STORAGE SYSTEM

14.3.1 The components of a Hydrogen System within a Removable Storage System shall fulfil all the requirements of this Regulation as if it were permanently installed in the vehicle unless otherwise stated below.

14.3.2 A Removable Storage System shall protect the Container(s) or Container Assembly and Hydrogen Components forming the Removable Storage System from damage during the handling operations necessary for installation, removal, storage and handling. The Manufacturer shall demonstrate that reasonable measures have been taken to the satisfaction of the Technical Service in charge of approval.

14.3.3 Effective measures shall be taken to prevent unauthorised removal of the Removable Storage System.
14.3.4 A single interface for the flow of hydrogen shall be provided between the Removable Storage System and the part of the Hydrogen System permanently installed in the vehicle. The Nominal Working Pressure of the Hydrogen System at the interface shall be less than or equal to 3.0 MPa.

14.3.5 When the Removable Storage System is installed in the vehicle the connection with the part of the Hydrogen System permanently installed in the vehicle shall be made without the use of tools and shall be capable of fulfilling the requirements of Paragraphs 14.1.10 and 14.2.4 of this Regulation.

14.3.6 At the time of disconnection of the Removable Storage System, the volume of hydrogen released shall not exceed 200Ncm³ and shall not be released near a possible ignition source. The build up of hydrogen due to successive disconnections shall be prevented.

14.3.7 The part of the Removable Storage System Connector permanently fitted to the vehicle shall be of a unique design for the applicable vehicle type and shall not be compatible with standard refilling nozzles for either hydrogen or other gaseous fuels.

14.3.8 The flow of hydrogen from a Removable Storage System shall be prevented if a Removable Storage System is installed with a higher Maximum Allowable Working Pressure than that of the permanent part of the vehicle's Hydrogen System.

14.3.9 Opening of the Automatic Valve(s) mounted on a Container(s) or a Container Assembly shall not be possible when the Removable Storage System is not correctly connected to the permanently fixed section of the vehicle's Hydrogen System. A vehicle interface system shall verify that a correct connection between the Removable Container System and the vehicle is established before permitting the Automatic Valve(s) to open. The vehicle interface system shall also verify that the Removable Storage System is compatible with the vehicle’s Hydrogen System before permitting the Automatic Valve(s) to open.

14.3.10 Disconnection or removal of the Removable Storage System shall not be possible unless the Automatic Valve mounted on a Container(s) or a Container Assembly is in the closed position and no combustion sources are in operation, for example, heaters on the vehicle.

14.3.11 Use of the Hydrogen System shall be prevented if a partial or total failure of the Removable Storage System Connector or electrical connectors between the Removable Storage System and the vehicle occurs, that may affect the safety of the Hydrogen System.

14.3.12 The installation and removal operations for the Removable Storage System shall be illustrated on a label attached to the vehicle close to the mounting point of the Removable Storage System. The label shall also state the Nominal Working Pressure of the Container(s) or Container Assembly and the Removable Storage System Connector.
14.3.13 A label shall be attached to the *Removable Storage System* stating the *Nominal Working Pressure* of the Container(s) or Container Assembly and the *Removable Storage System Connector*.

14.3.14 The vehicle type approval mark specified in Paragraph 13.4 of this Regulation shall be reproduced on the *Removable Storage System*.

14.4 **AUTOMATIC VALVE(S) OR NON-RETURN VALVE(S) FOR ISOLATING A CONTAINER OR CONTAINER ASSEMBLY**

14.4.1 The flow of hydrogen from a *Container or Container Assembly* into the *Fuel Supply Line* shall be secured with an *Automatic Valve* (idle closed). This valve shall be mounted directly on or within either every *Container* or one *Container* in a *Container Assembly*.

14.4.2 The *Receptacle* shall be integrated with a *Non-return Valve*. If the *Receptacle* is not mounted directly on either the *Container* or one *Container* in a *Container Assembly*, the refilling line shall be secured by a *Non-return Valve* or an *Automatic Valve* integrating the function of a *Non-return Valve*. This valve shall be mounted directly on either the *Container* or one *Container* in a *Container Assembly*.

14.4.3 If a single line is used into the *Container* or *Container Assembly* for both refilling and fuel supply, it shall be secured as described in Paragraph 14.4.2 of this Regulation on the refilling line at the junction between the refilling line and the *Fuel Supply Line*.

14.4.4 In the event of breakage of the refilling lines or *Fuel Supply Line(s)*, the isolating valves referred to in Paragraphs 14.4.1 and 14.4.2 of this Regulation shall not be separated from the *Container* or *Container Assembly*.

14.4.5 *Automatic Valve(s)* isolating each *Container* or *Container Assembly*, shall close in the event of either a malfunction of the *Hydrogen System* that results in the release of hydrogen or severe leakage between the *Container* or *Container Assembly* and the *Hydrogen Conversion System(s)*.

14.4.6 The *Automatic Valve* for the *Fuel Supply Line* of the *Propulsion System* shall be operated such that the hydrogen supply to the *Propulsion System* is cut off when the *Propulsion System* is switched off, irrespective of the position of the activation switch, and shall remain so until the *Propulsion System* is required to operate.

14.4.7 The *Automatic Valve* for the *Fuel Supply Line* of other *Hydrogen Conversion System(s)* shall be operated such that the hydrogen supply to other *Hydrogen Conversion System(s)* is cut off when the respective *Hydrogen Conversion System* is switched off, irrespective of the position of the activation switch, and shall remain so until the *Hydrogen Conversion System* is required to operate.

14.5 **PRESSURE RELIEF DEVICE(S)**

14.5.1 A *Pressure Relief Device* shall be directly installed into the opening of a *Container* or at least one *Container* in a *Container Assembly*, or into an
opening in a valve assembled into the Container, in such a manner that it shall discharge the hydrogen into an atmospheric outlet that vents to the outside of the vehicle.

14.5.2 It shall not be possible to isolate the Pressure Relief Device from the Hydrogen Components or section of the Hydrogen System protected by the Pressure Relief Device, by the normal operation or failure of another component.

14.5.3 The vent of a Pressure Relief Device shall not discharge into a wheel arch, nor shall it be aimed at a heat source such as the exhaust or at other Containers or Container Assemblies if fitted. Additionally it shall discharge such that hydrogen cannot enter the inside of the vehicle.

14.5.4 The internal dimensions of the vent shall not impede the function of the Pressure Relief Device.

14.5.5 The vent of the Pressure Relief Device shall be protected against blockage, e.g. by dirt, ice, and ingress of water etc., so far as is reasonably practicable.

14.5.6 The outlet of the Pressure Relief Device shall be orientated such that if the vent becomes detached from the Pressure Relief Device, the resulting gas flow does not impinge directly on other Containers or Container Assemblies unless they are protected.

14.6 PRESSURE RELIEF VALVE(S)

14.6.1 A Pressure Relief Valve shall be installed in such a manner that it shall discharge the hydrogen into an atmospheric outlet that vents to the outside of the vehicle.

14.6.2 It shall not be possible to isolate the Pressure Relief Valve from the Hydrogen Components or section of the Hydrogen System that it protects, by the normal operation or failure of another component.

14.6.3 The vent of a Pressure Relief Valve shall not discharge into a wheel arch, nor shall it be aimed at a heat source such as the exhaust or at any Container or Container Assembly. Additionally it shall discharge such that hydrogen cannot enter the inside of the vehicle.

14.6.4 The vent of the Pressure Relief Valve shall be protected against blockage, e.g. by dirt, ice, and ingress of water etc., so far as is reasonably practicable.

14.7 RIGID AND FLEXIBLE FUEL LINES

14.7.1 Rigid Fuel Lines shall be secured such that they shall not be subjected to critical vibration or other stresses.

14.7.2 Flexible Fuel Lines shall be secured such that they shall not be subjected to torsional stresses and abrasion is avoided.
14.7.3 **Rigid Fuel Lines** and **Flexible Fuel Lines** shall be mounted to reasonably minimise stresses in the lines during removal or installation of adjoining **Hydrogen Components**. 

14.7.4 At fixing points, **Rigid Fuel Lines** and **Flexible Fuel Lines** shall be fitted in such a way that they cannot make metal to metal contact, to prevent galvanic and crevice corrosion.

14.7.5 **Rigid Fuel Lines** and **Flexible Fuel Lines** shall be routed to reasonably minimise exposure to accidental damage whether inside the vehicle, e.g. due to placing or movement of luggage or other loads, or outside the vehicle, e.g. due to rough ground or vehicle jacks etc.

14.7.6 At passages through the vehicle body or other **Hydrogen Components**, the fuel lines shall be fitted with grommets or other protective material.

14.7.7 In the passenger or enclosed luggage compartment the fuel lines shall be enclosed in a sleeve which meets the same requirements as specified for a gas tight housing in **Paragraph 14.10** of this Regulation.

14.7.8 Class 0 metallic **Rigid Fuel Lines** shall be seamless and shall elongate by at least 14% before rupture.

14.8 **FITTINGS BETWEEN HYDROGEN COMPONENTS**

14.8.1 *Fittings* for stainless steel fuel lines shall only be stainless steel *Fittings*.

14.8.2 The number of joints shall be limited to a minimum.

14.8.3 Any joints shall be made in locations where access is possible for inspection and also for leak testing.

14.9 **REFILLING SYSTEM**

14.9.1 The **Receptacle** shall be secured against maladjustment and rotation. The **Receptacle** shall also be protected from unauthorised interference, and the ingress of dirt and water so far as is reasonably practicable, e.g. a locked hatch. It shall be safe against reasonably foreseeable handling errors.

14.9.2 The **Receptacle** shall be installed such that access for refilling shall not be required in the passenger, luggage, or in any other unventilated compartment.

14.9.3 The refilling line shall be secured at the **Container** or **Container Assembly** or at the junction of the refilling line and the **Fuel Supply Line** as described in **Paragraph 14.4.2** of this Regulation.

14.9.4 The **Receptacle** shall not be mounted within the external energy absorbing elements, e.g. bumper.

14.9.5 The **Nominal Working Pressure** of the **Receptacle** shall be equal to the **Nominal Working Pressure** of the Class 0 **Hydrogen Components** upstream of and including the **First Pressure Regulator**.
14.9.6 It shall be ensured that, where fitted, the Propulsion System or Hydrogen Conversion System(s) excluding Safety Devices are not operating and that the vehicle is immobilised while the Receptacle is connected to the refilling infrastructure.

14.9.7 A label shall be provided close to the Receptacle, for example, inside a refilling hatch, showing the following information:

\[
\text{H}_2 \text{ GAS} \\
\text{“xx” MPa}
\]

where “xx" = Nominal Working Pressure of the Container(s).

14.10 GAS TIGHT HOUSING

14.10.1 The gas tight housing shall be vented to the atmosphere.

14.10.2 The ventilation opening of the gas tight housing shall be at the highest point of the housing when installed in the vehicle. It shall not ventilate into a wheel arch, nor shall it be aimed at a heat source such as the exhaust. Additionally it shall vent such that hydrogen cannot enter the inside of the vehicle.

14.10.3 There shall be no unprotected ignition sources inside the gas tight housing.

14.10.4 During testing the vent line shall be hermetically sealed and the gas tight housing shall then meet the leakage requirements of Paragraph 14.1.10 of this Regulation at an over pressure of 0.01 MPa and without any permanent deformations.

14.10.5 Any connecting system shall be secured by clamps, or other means, to the gas tight housing or sleeve and the lead-through to ensure that a joint is formed meeting the leakage requirements of Paragraph 14.10.4 of this Regulation.

14.11 ELECTRICAL INSTALLATION

14.11.1 The electrical components of the Hydrogen System shall be protected against overloads.

14.11.2 The electrical connections and components in the gas tight housing shall be-constructed such that no sparks are generated.

14.11.3 The metallic components of the Hydrogen System shall have electrical continuity with the vehicle’s earth, e.g. chassis.

14.11.4 During the refilling process the Hydrogen System shall have electrical continuity with the refilling facilities before hydrogen transfer is permitted.

14.11.5 Where Hydrogen Components are present or hydrogen leaks are possible, electrical connections for power supply bushing shall not permit the ingress of Leak Test Gas when pressurised at an external overpressure of 0.01 MPa.

14.12 SAFETY INSTRUMENTED SYSTEMS
14.12.1 *Safety Instrumented Systems* shall be fail-safe or redundant.

14.12.2 If *Safety Instrumented Systems* are fail-safe or self-monitoring electronic systems, the special requirements according to Annex 9 to this Regulation are to be applied.

14.13 INFORMATION FOR PERIODIC REQUALIFICATION

The vehicle manufacturer shall provide information for periodic requalification by inspection during the *Service Life* on the basis of use under the service conditions specified in Paragraph 2.4 of this Regulation. The information shall include the following items:

i) Frequency of the periodic requalification inspection,

ii) Check of the mandatory markings on the *Container, Container Assembly, or Removable Storage System* (as applicable).

iii) Visual inspection of the *Container or Container Assembly*,

iv) Inspection of the *Pressure Relief Device(s), Pressure Relief Valve(s)*, and associated vents,

v) Inspection of the *Automatic Valve(s)*,

vi) Inspection of other *Hydrogen Components* directly mounted on the *Container or Container Assembly* and other safety related components,

vii) Check of the gas tightness of the *Hydrogen System*.

14.14 IDENTIFICATION OF VEHICLES OF CATEGORIES M2 AND M3 EQUIPPED WITH A HYDROGEN SYSTEM

14.14.1 Vehicles of categories M2 and M3 equipped with a *Hydrogen System* shall carry a label as specified in Annex 10 to this Regulation.

14.14.2 The label shall be installed on the front and rear of the vehicle and one to the side of each set of doors.

15 MODIFICATION OF A VEHICLE TYPE OR HYDROGEN SYSTEM AND EXTENSION OF APPROVAL

15.1 Every modification of the *Vehicle Type* or of its installation of *Specific Components* for the use of hydrogen shall be notified to the Administrative Department that granted approval of the *Vehicle Type*. The Administrative Department may then either:

i) Consider that the modifications made are unlikely to have an appreciably adverse effect, and that the vehicle still complies with the requirements of this Regulation; or

ii) Require a further report from the Technical Service responsible for carrying out the tests.

15.2 Notice of confirmation, extension or refusal of approval shall be communicated by the procedure specified in Paragraph 13.3 of this Regulation to the Parties to the Agreement that apply this Regulation.

15.3 The competent authority issuing the extension of approval shall assign a series number to each communication form (specified in Paragraph 13.3 of this Regulation) issued for such an extension.
16 CONFORMITY OF PRODUCTION

The conformity of production procedures shall comply with those set out in the Agreement, Appendix 2 (E/ECE/324- E/ECE/TRANS/505/rev.2) and with the following requirements:

i) A Vehicle Type, type approved according to this Regulation shall be manufactured so as to conform to the type approved by meeting the requirements specified in Paragraph 14 of this Regulation.

ii) The approval authority that has granted type approval may at any time verify the conformity control methods applied in each production facility. The normal frequency of these verifications shall be once every two years.

17 PENALTIES FOR NON-CONFORMITY OF PRODUCTION

17.1 The type approval granted in respect of a Vehicle Type in accordance with this Regulation may be withdrawn if the requirements laid down in Paragraph 16 of this Regulation are not complied with.

17.2 If a Contracting Party to the Agreement that applies this Regulation withdraws an approval it has previously granted, it shall immediately notify the other Contracting Parties applying this Regulation by means of a communication form conforming to the model in Annex 6 to this Regulation.

18 PRODUCTION DEFINITELY DISCONTINUED

If the holder of the approval permanently ceases to manufacture a type of vehicle approved in accordance with this Regulation, he shall immediately inform the authority that granted the approval. Upon receiving the relevant communication, that authority shall inform the other Parties to the Agreement applying this Regulation, by means of a communication form conforming to the model in Annex 6 to this Regulation.

19 NAMES AND ADDRESSES OF TECHNICAL SERVICES RESPONSIBLE FOR CONDUCTING APPROVAL TESTS AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the Technical Services responsible for conducting approval tests and of the Administrative Departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval issued in other countries, are to be sent.
ESSENTIAL CHARACTERISTICS OF SPECIFIC COMPONENTS

1 Automatic Valve:
   1.1 Make:
   1.2 Type:
   1.3 Description and drawings:
   1.4 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa
   1.5 Material(s):
   1.6 Number of Filling Cycles or Duty Cycles as appropriate:

2 Non-return Valve:
   2.1 Make:
   2.2 Type:
   2.3 Description and drawings:
   2.4 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa
   2.5 Material(s):
   2.6 Number of Filling Cycles or Duty Cycles as appropriate:

3 Container and Container Assembly:
   A statement of service shall be provided in accordance with the requirements of Annex 7 to this Regulation.

4 Fittings:
   4.1 Make:
   4.2 Type:
   4.3 Description and drawings:
   4.4 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa
   4.5 Material(s):
   4.6 Number of Filling Cycles or Duty Cycles as appropriate:
5 **Flexible Fuel Lines:** yes/no

5.1 Make:

5.2 Type:

5.3 Description and drawings:

5.4 *Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s)*:

5.5 Material(s):

5.6 Number of **Filling Cycles** or Duty Cycles as appropriate:

6 **Heat exchanger:** yes/no

6.1 Make:

6.2 Type:

6.3 Description and drawings:

6.4 *Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s)*:

6.5 Material(s):

6.6 Number of **Filling Cycles** or Duty Cycles as appropriate:

7 **Hydrogen Filter:** yes/no

7.1 Make:

7.2 Type:

7.3 Description and drawings:

7.4 *Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s)*:

7.5 Material(s):

7.6 Number of **Filling Cycles** or Duty Cycles as appropriate:

8 **Manual Valve:** yes/no

8.1 Make:

8.2 Type:

8.3 Description and drawings:
8.4 *Nominal Working Pressure(s)* and if downstream of the *First Pressure Regulator, Maximum Allowable Working Pressure(s)* $^{*2}$: $\text{MPa}$

8.5 Material(s):

8.6 Number of *Filling Cycles or Duty Cycles* as appropriate:

9 Pressure or temperature or flow sensor$^1$: yes/no $^1$

9.1 Make:

9.2 Type:

9.3 Operating principles including description and drawings:

9.4 *Nominal Working Pressure(s)* and if downstream of the *First Pressure Regulator, Maximum Allowable Working Pressure(s)* $^{*2}$: $\text{MPa}$

9.5 Material(s):

9.6 Number of *Filling Cycles or Duty Cycles* as appropriate:

10 *Pressure Regulator*: yes/no $^1$

10.1 Make:

10.2 Type:

10.3 Drawings:

10.4 Number of main adjustment points:

10.5 Description of principle of adjustment through main adjustment points:

10.6 Number of idle adjustment points:

10.7 Description of principles of adjustment through idle adjustment points:

10.8 Other adjustment possibilities: if so and which (description and drawings):

10.9 *Nominal Working Pressure(s)* and if downstream of the *First Pressure Regulator, Maximum Allowable Working Pressure(s)* $^{*2}$: $\text{MPa}$

10.10 Number of *Filling Cycles or Duty Cycles* as appropriate:

11 *Pressure Relief Device*:

11.1 Make:

11.2 Type:

11.3 Description and drawings:

11.4 Normal maximum operating temperature: $^{*2}$ $\text{°C}$
(in accordance with Paragraph 2.4.5 of this Regulation)

11.5 Nominal Working Pressure(s) *2: MPa

11.6 Material:

11.7 Set (trigger) temperature: *2

11.8 Number of Filling Cycles (Class 0 only):

12 Pressure Relief Valve: yes/no *1

12.1 Make:

12.2 Type:

12.3 Description and drawings:

12.4 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

12.5 Material:

12.6 Set pressure: *2

13.7 Number of Duty Cycles:

13 Receptacle:

13.1 Make:

13.2 Type:

13.3 Operating principles including description and drawings:

13.4 Nominal Working Pressure *2: MPa

13.5 Material:

13.6 Number of Filling Cycles (Class 0 only):

14 Removable Storage System Connector:

14.1 Make:

14.2 Type:

14.3 Operating principles including description and drawings:

14.4 Nominal Working Pressure(s) and Maximum Allowable Working Pressure(s) *2: MPa

14.5 Material:
14.6 Number of *Duty Cycles*:

Notes:

*¹ - Strike out what does not apply.

*² - Specify the tolerance.
Annex 2

ESSENTIAL CHARACTERISTICS OF THE VEHICLE, HYDROGEN RELATED PROPULSION SYSTEM AND OTHER HYDROGEN RELATED SYSTEMS

0 Description Of The Vehicle Type

0.1 Make:

0.2 Type(s):

0.3 Name and address of the vehicle manufacturer:

1 Description Of The Hydrogen System Used For The propulsion Of The Vehicle *

1.1 Description of the Propulsion System:

1.2 Name and address of the Manufacturer:

1.3 Manufacturer's Propulsion System code(s) (as marked on the Propulsion System, or other means of identification):

1.4 Automatic Valve(s):

1.4.1 Make(s):

1.4.2 Type(s):

1.4.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) **: MPa

1.4.4 Approval number:

1.4.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.5 Non-return Valve(s):

1.5.1 Make(s):

1.5.2 Type(s):

1.5.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) **: MPa

1.5.4 Approval number:

1.5.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.6 Container(s) and Container Assembly:

1.6.1 Make(s):

1.6.2 Type(s):
1.6.3 Capacity: litres (water)

1.6.4 Approval number

1.6.5 Nominal Working Pressure: MPa

1.6.6 Number of Filling Cycles:

1.7 Excess Flow System:

1.7.1 Make(s):

1.7.2 Type(s):

1.7.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.8 Fittings:

1.8.1 Make(s):

1.8.2 Type(s):

1.8.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.8.4 Approval number:

1.8.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.9 Flexible Fuel Lines(s): yes/no *1

1.9.1 Make(s):

1.9.2 Type(s):

1.9.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.9.4 Approval number:

1.9.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.10 Heat exchanger(s): yes/no *1

1.10.1 Make(s):

1.10.2 Type(s):

1.10.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa
1.10.4 Approval number:

1.10.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.11 Hydrogen Filter(s): yes/no *1

1.11.1 Make(s):

1.11.2 Type(s):

1.11.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.11.4 Approval number:

1.11.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.12 Manual Valve(s): yes/no *1

1.12.1 Make(s):

1.12.2 Type(s):

1.12.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.12.4 Approval number:

1.12.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.13 Pressure or temperature or flow sensor(s) *1: yes/no *1

1.13.1 Make(s):

1.13.2 Type(s):

1.13.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.13.4 Approval number:

1.13.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.14 Pressure Regulator(s): yes/no *1

1.14.1 Make(s):

1.14.2 Type(s):

1.14.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

1.14.4 Approval number:
1.14.5 Number of Filling Cycles or Duty Cycles as appropriate:

1.15 Pressure Relief Device:

1.15.1 Make(s):

1.15.2 Type(s):

1.15.3 Normal maximum operating temperature: °C
   (in accordance with Paragraph 2.4.5 of this Regulation)

1.15.4 Approval number:

1.15.5 Nominal Working Pressure(s) *2:  MPa

1.15.6 Number of Filling Cycles (Class 0 only):

1.16 Pressure Relief Valve: yes/no *1

1.16.1 Make(s):

1.16.2 Type(s):

1.16.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2:  MPa

1.16.4 Approval number:

1.16.5 Number of or Duty Cycles as appropriate:

1.17 Receptacle:

1.17.1 Make(s):

1.17.2 Type(s):

1.17.3 Nominal Working Pressure: °MPa

1.17.4 Approval number:

1.17.5 Number of Filling Cycles (Class 0 only):

1.18 Removable Storage System Connector:

1.18.1 Make(s):

1.18.2 Type(s):

1.18.3 Nominal Working Pressure(s) and Maximum Allowable Working Pressure(s) *2:  MPa

1.18.4 Approval number:

1.18.5 Number of Duty Cycles:
2 Description Of The Hydrogen System(s) Used For Purposes Other Than The Propulsion Of The Vehicle *1

2.1 Description of the Hydrogen System(s):

2.2 Name and address of the Manufacturer(s):

2.3 Manufacturer's system code(s) (as marked on the system, or other means of identification):

2.4 Automatic Valve(s): yes/ same component as used in Propulsion System *1
   2.4.1 Make(s):
   2.4.2 Type(s):
   2.4.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa
   2.4.4 Approval number:
   2.4.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.5 Non-return Valve(s): yes/ same component as used in Propulsion System *1
   2.5.1 Make(s):
   2.5.2 Type(s):
   2.5.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa
   2.5.4 Approval number:
   2.5.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.6 Container(s) and Container Assembly: yes/ same component as used in Propulsion System *1
   2.6.1 Make(s):
   2.6.2 Type(s):
   2.6.3 Capacity: litres (water)
   2.6.4 Approval number
   2.6.5 Nominal Working Pressure *2: MPa
   2.6.6 Number of Filling Cycles:

2.7 Excess Flow System: yes/ same component as used in Propulsion System *1
2.7.1 Make(s):

2.7.2 Type(s):

2.7.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

2.8 Fittings: yes/ same component as used in Propulsion System *1

2.8.1 Make(s):

2.8.2 Type(s):

2.8.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

2.8.4 Approval number:

2.8.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.9 Flexible Fuel Lines(s): yes/no/same component as used in Propulsion System *1

2.9.1 Make(s):

2.9.2 Type(s):

2.9.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

2.9.4 Approval number:

2.9.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.10 Heat exchanger(s): yes/no/same component as used in Propulsion System *1

2.10.1 Make(s):

2.10.2 Type(s):

2.10.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) *2: MPa

2.10.4 Approval number:

2.10.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.11 Hydrogen Filter(s): yes/no/same component as used in Propulsion System *1

2.11.1 Make(s):

2.11.2 Type(s):
2.11.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) \(^2\): \(\text{MPa}\)

2.11.4 Approval number:

2.11.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.12 Manual Valve(s): yes/no/same component as used in Propulsion System \(^1\)

2.12.1 Make(s):

2.12.2 Type(s):

2.12.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) \(^2\): \(\text{MPa}\)

2.12.4 Approval number:

2.12.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.13 Pressure or temperature or flow sensor(s) \(^1\): yes/no/same component as used in Propulsion System \(^1\)

2.13.1 Make(s):

2.13.2 Type(s):

2.13.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) \(^2\): \(\text{MPa}\)

2.13.4 Approval number:

2.13.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.14 Pressure Regulator(s): yes/no/same component as used in Propulsion System \(^1\)

2.14.1 Make(s):

2.14.2 Type(s):

2.14.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) \(^2\): \(\text{MPa}\)

2.14.4 Approval number:

2.14.5 Number of Filling Cycles or Duty Cycles as appropriate:

2.15 Pressure Relief Device: yes/ same component as used in Propulsion System \(^1\)

2.15.1 Make(s):

2.15.2 Type(s):
2.15.3 Normal maximum operating temperature: \(^{2}\) °C
(in accordance with Paragraph 2.4.5 of this Regulation)

2.15.4 Approval number:

2.15.5 Nominal Working Pressure(s) \(^{2}\): MPa

2.15.6 Number of Filling Cycles (Class 0 only):

2.16 Pressure Relief Valve: yes/no/same component as used in Propulsion System \(^{4}\)

2.16.1 Make(s):

2.16.2 Type(s):

2.16.3 Nominal Working Pressure(s) and if downstream of the First Pressure Regulator, Maximum Allowable Working Pressure(s) \(^{2}\): MPa

2.16.4 Approval number:

2.16.5 Number of Duty Cycles:

2.17 Receptacle: yes/same component as used in Propulsion System \(^{4}\)

2.17.1 Make(s):

2.17.2 Type(s):

2.17.4 Nominal Working Pressure \(^{2}\): MPa

2.17.4 Approval number:

2.17.5 Number of Filling Cycles (Class 0 only):

2.18 Removable Storage System Connector:

2.18.1 Make(s):

2.18.2 Type(s):

2.18.3 Nominal Working Pressure(s) and Maximum Allowable Working Pressure(s) \(^{2}\): MPa

2.18.4 Approval number:

2.18.5 Number of Duty Cycles:

3 Further documentation:

3.1 Process diagram (flow chart) for the Hydrogen System
3.2 System layout including electrical connections, and other external system inputs or outputs, etc.

3.3 Key to symbols used in documentation:

3.4 Adjustment data:

3.5 Cooling/ heating system(s) including *Nominal* or *Maximum Allowable Working Pressures* and normal operating temperatures

3.6 Drawings showing requirements for installation and operation.

Notes:

*1 - Strike out what does not apply.

*2 - Specify the tolerance.
Annex 3

ARRANGEMENT OF THE SPECIFIC COMPONENT APPROVAL MARKS
(See Paragraph 5.4 of this Regulation)

Where: $a \geq 4 \text{ mm}$

The above approval mark affixed to the Hydrogen Component shows that this component has been type approved in Germany (E1), pursuant to the Regulation No. xx under approval number 002439. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No. xx in its original form.
Annex 4

COMMUNICATION CONCERNING THE APPROVAL, OR REFUSAL, OR EXTENSION, OR WITHDRAWAL, OR PRODUCTION DEFINITELY DISCONTINUED OF A SPECIFIC COMPONENT PURSUANT TO REGULATION NO. XX
(Maximum format: A4 (210 x 297 mm)

Issued by: Name of administration:

Concerning: APPROVAL GRANTED *2
APPROVAL EXTENDED *2
APPROVAL REFUSED *2
APPROVAL WITHDRAWN *2
PRODUCTION DEFINITELY DISCONTINUED *2

of a Specific Component pursuant to Regulation No. XX

Approval No.: .................................. Extension No.: ................…………

1. Specific Component considered:
   Automatic Valve *2
   Non-return Valve *2
   Container *2
   Fittings *2
   Flexible Fuel Line *2
   Heat exchanger *2
   Hydrogen Filter
   Hydrogen Sensor
   Manual Valve *2
   Pressure sensor *2
   Temperature sensor *2
   Flow sensor *2
   Pressure or hydrogen remaining indicator
   Pressure Regulator *2
   Pressure Relief Device *2
   Pressure Relief Valve *2
   Receptacle *2
   Removable Storage System Connector *2
2. Trade name or mark: .................................................................
3. Manufacturer's name and address: ...........................................

4. Nominal Working Pressure/MAWP \(^*2\) = .................................. MPa
   Operating Temperature Range: -40°C to +85/+105/+120°C\(^*2\)
   Number of Filling Cycles or Duty Cycles \(^*2\): .................................
   Service Life: ............................................. years
5. If applicable, name and address of Manufacturer's representative: .......
6. Submitted for approval on: ..........................................................
7. Technical Service responsible for conducting approval tests: .......... 
8. Date of report issued by that service: ............................................
9. No. of report issued by that service: .............................................
10. Approval granted/refused/extended/withdrawn \(^*2\)
11. Reason(s) of extension (if applicable): ........................................
12. Place: .............................................................................
13. Date: ..............................................................................
14. Signature: .......................................................................... 
15. The documents filed with the application or extension of approval can be obtained upon request.

Notes:
\(^*1\) Distinguishing number of the country that has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).
\(^*2\) Strike out what does not apply
Annex 5

ARRANGEMENTS OF APPROVAL MARKS FOR A VEHICLE TYPE WITH REGARD TO THE INSTALLATION OF A HYDROGEN SYSTEM

Model A
(See Paragraph 13.4 of this Regulation)

Where: \( a \geq 8 \) mm

The above approval mark affixed to a vehicle shows that the vehicle has, with regard to the installation of a Hydrogen System for the use of compressed gaseous hydrogen, has been type approved in Germany (E1), pursuant to the Regulation No. xx under approval number 002439. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No. xx in its original form.

Model B
(See Paragraph 13.4 of this Regulation)

Where: \( a \geq 8 \) mm

The above approval mark affixed to a vehicle shows that the vehicle has been type approved in Germany (E1), pursuant to the Regulation Nos. xx and 83. The approval numbers indicate that, at the dates when the respective approvals were given, Regulation No. xx was in its original form and Regulation No. 83 included the 02 series of amendments.
Annex 6

COMMUNICATION CONCERNING THE APPROVAL, OR REFUSAL, OR EXTENSION, OR WITHDRAWAL, OR PRODUCTION DEFINITELY DISCONTINUED OF A VEHICLE TYPE WITH REGARD TO THE INSTALLATION OF A HYDROGEN SYSTEM PURSUANT TO REGULATION NO. XX

(Maximum format: A4 (210 x 297 mm)

Issued by: Name of administration:

Concerning: APPROVAL GRANTED *2
APPROVAL EXTENDED *2
APPROVAL REFUSED *2
APPROVAL WITHDRAWN *2
PRODUCTION DEFINITELY DISCONTINUED *2

of a Vehicle Type with regard to the installation of a Hydrogen System pursuant to Regulation No. XX

Approval No.: ................................ Extension No.: ...........................................

1. Trade name or mark of vehicle: ...........................................................

2. Vehicle Type: .............................................................................

3. Vehicle category: ........................................................................

4. Vehicle manufacturer’s name and address: ......................................................

5. If applicable, name and address of vehicle manufacturer’s representative: . . . .

6. Description of the vehicle with regard to the installation of Hydrogen System (add drawing if appropriate): ..........................................................

7. Hydrogen System

7.1 Trade name or mark of components and their approval numbers:

7.1.1 Container or Container Assembly: ......................................................

7.1.2 Other components: .................................................................
8. Submitted for approval on: 

9. Technical Service responsible for conducting approval tests: 

10. Date of report issued by that service: 

11. No. of report issued by that service: 

12. Approval granted/refused/extended/withdrawn  

13. Reason(s) of extension (if applicable): 

14. Place: 

15. Date: 

16. Signature: 

17. The documents filed with the application or extension of approval can be obtained upon request.

Drawings, diagrams and scheme plans regarding the components and the installation of the Hydrogen System considered to be of importance for the purpose of this Regulation:

Where applicable drawings of the various equipment and their position in the vehicle:

__________

Notes:

*1 Distinguishing number of the country that has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).

*2 Strike out what does not apply
# Annex 7

**Requirements and Approval Test Procedures for Containers**

## Contents

<table>
<thead>
<tr>
<th>Part A</th>
<th>PROVISIONS REGARDING THE APPROVAL OF CONTAINERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>References</td>
</tr>
<tr>
<td>A2</td>
<td>General Requirements</td>
</tr>
<tr>
<td>A3</td>
<td>Approval Requirements</td>
</tr>
<tr>
<td>A4</td>
<td>Container Manufacturing Requirements</td>
</tr>
<tr>
<td>A5</td>
<td>Batch Test Requirements</td>
</tr>
<tr>
<td>A6</td>
<td>Production Examination And Test requirements</td>
</tr>
<tr>
<td>A7</td>
<td>Modifications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part B</th>
<th>APPROVAL TEST PROCEDURES FOR CONTAINERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Tensile Test</td>
</tr>
<tr>
<td>B2</td>
<td>Softening/Melting Temperature Test</td>
</tr>
<tr>
<td>B3</td>
<td>Glass Transition Temperature Test</td>
</tr>
<tr>
<td>B4</td>
<td>Resin Shear Strength Test</td>
</tr>
<tr>
<td>B5</td>
<td>Coating Test</td>
</tr>
<tr>
<td>B6</td>
<td>Coating Batch Test</td>
</tr>
<tr>
<td>B7</td>
<td>Hydrogen Compatibility Test</td>
</tr>
<tr>
<td>B8</td>
<td>Hardness Test</td>
</tr>
<tr>
<td>B9</td>
<td>Burst Test</td>
</tr>
<tr>
<td>B10</td>
<td>Ambient Temperature Pressure Cycling Test</td>
</tr>
<tr>
<td>B11</td>
<td>LBB Performance Test</td>
</tr>
<tr>
<td>B12</td>
<td>Bonfire Test</td>
</tr>
<tr>
<td>B13</td>
<td>Penetration Test</td>
</tr>
<tr>
<td>B14</td>
<td>Chemical Exposure Test</td>
</tr>
<tr>
<td>B15</td>
<td>Composite Flaw Tolerance Test</td>
</tr>
<tr>
<td>B16</td>
<td>Accelerated Stress Rupture Test</td>
</tr>
<tr>
<td>B17</td>
<td>Extreme Temperature Pressure Cycling Test</td>
</tr>
<tr>
<td>B18</td>
<td>Impact Damage Test</td>
</tr>
<tr>
<td>B19</td>
<td>Leak Test</td>
</tr>
<tr>
<td>B20</td>
<td>Permeation Test</td>
</tr>
<tr>
<td>B21</td>
<td>Boss Torque Test</td>
</tr>
<tr>
<td>B22</td>
<td>Hydrogen Gas Cycling Test</td>
</tr>
<tr>
<td>B23</td>
<td>Hydraulic Test</td>
</tr>
</tbody>
</table>
Annex 7: Part A

PROVISIONS REGARDING THE APPROVAL OF CONTAINERS

A1 REFERENCES

The following standards contain provisions that, through reference in this text, constitute provisions of this Annex. Where standards other than ISO standards are referenced they may be replaced by equivalent national standards.

International Organisation for Standardization (ISO) Standards

ISO 2808:1997  Paints And Varnishes - Determination Of Film Thickness
ISO 3146:2000/ Cor 1:2002  Plastics - Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers by capillary tube and polarizing-microscope methods
ISO 4624:2002  Paints And Varnishes - Pull-off Test For Adhesion
ISO 7225:1994  Gas cylinders - Precautionary labels
ISO 9809-1:1999  Gas Cylinders - Refillable Seamless Steel Gas Cylinders - Design, Construction And Testing - Part 1: Quenched And Tempered Steel Cylinders With Tensile Strength Less Than 1100 MPa
ISO 9809-2:2000  Gas Cylinders - Refillable Seamless Steel Gas Cylinders - Design, Construction And Testing - Part 2: Quenched And Tempered Steel Cylinders With Tensile Strength Greater Than Or Equal To 1 100 MPa

European Committee for Standardization (CEN) Standards

EN 1964-3:2000  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 3: Cylinders Made Of Seamless Stainless Steel With An Rm Value Of Less Than 1100 MPa
A2 GENERAL REQUIREMENTS

A2.1 GENERAL

The service conditions do not include external loads that may arise from vehicle collisions, or integration of the Container into the vehicle, etc. Containers need not be designed for continuous exposure to mechanical or chemical attack, e.g. leakage from cargo that may be carried on vehicles or severe abrasion damage from road conditions.

A2.2 FIRE PROTECTION

The Container, Pressure Relief Device(s) and any added insulation or protective material shall collectively protect the Container from rupture when exposed to fire. The arrangement of the fire protection system shall be specified.

A2.3 OPENING THREADS
Openings with tapered or straight threads may be used in all Container Types. Threads shall comply with a recognised international or national standard. Threads shall be clean cut, even, without surface discontinuities, and to gauge.

A2.4 EXTERIOR ENVIRONMENTAL PROTECTION

Any coatings applied to Containers shall be such that the application process does not adversely affect the mechanical properties of the Container. The coating shall facilitate subsequent in-service inspection and the Manufacturer shall provide guidance on coating treatment during such inspection to ensure the continued integrity of the Container.

A3 APPROVAL REQUIREMENTS

A3.1 GENERAL

In addition to the requirements given in Paragraph 3 of this Regulation, the Manufacturer shall complete all documents referred to in Table 7A.1 and submit them to the Competent Authority when applying for approval.

Table 7A.1 – Container Type Approval Documents

<table>
<thead>
<tr>
<th>Document</th>
<th>Annex 7 Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement Of Service</td>
<td>A3.2</td>
</tr>
<tr>
<td>Container Drawings</td>
<td>A3.3</td>
</tr>
<tr>
<td>Material Specifications and Test Data</td>
<td>A3.4</td>
</tr>
<tr>
<td>Container Specifications and Test Data</td>
<td>A3.5</td>
</tr>
<tr>
<td>Manufacturing Data</td>
<td>A3.6</td>
</tr>
<tr>
<td>Stress Analysis</td>
<td>A3.7</td>
</tr>
</tbody>
</table>

A3.2 STATEMENT OF SERVICE

The Manufacturer's statement of service and all necessary information to ensure the proper handling, use and in-service inspection of the Container shall be supplied to the purchaser of the Container.

The statement of service shall include the information given in Table 7A.2 as a minimum.

A3.3 CONTAINER DRAWINGS

Drawings shall show the following information as a minimum:

i) Title, reference number, date of issue and revision number,

ii) Reference to this Regulation and the Container Type,

iii) Principal geometrical dimensions including tolerances,

iv) Container materials,

v) Container mass and internal volume including tolerances,

vi) Details of the exterior protective coating,
vii) **Container** fire protection system.

**A3.4 MATERIAL SPECIFICATIONS AND TEST DATA**

A detailed description of all principal material properties and tolerances used in the **Container** design shall be provided according to Table 7A.3. The material specifications shall be verified by appropriate material tests and the results from these tests shall be provided according to Table 7A.3.

If more samples than required are tested, all results shall be documented.

**A3.5 CONTAINER SPECIFICATIONS AND TEST DATA**

Type approval tests shall be conducted on **Finished Containers** that are representative of normal production and complete with identification marks.

The **Container** design specifications for each test that is required shall be provided according to Table 7A.4. The design specifications shall be verified by appropriate **Container** tests and the results from these tests shall be provided according to Table 7A.4.

All results shall be documented if more **Containers** or **Liners** than required are tested.

**A3.6 MANUFACTURING DATA**

Manufacturing data, including tolerances where appropriate, shall be provided, such as:

i) Tube extrusion, cold deformation, tube drawing, end forming, welding, heat treatment and cleaning processes for the metal manufacturing of Type 1, 2 and 3 **Containers**,

ii) Acceptance criteria for non-destructive examination (NDE),

iii) Composite manufacturing processes and **Auto-frettage** according to Paragraph A4.2 of this Annex for the manufacturing of Type 2, 3 and 4 **Containers**,

iv) Final manufacturing inspection of surface finish, thread details and principal dimensions.
### Table 7A.2 – Statement Of Service

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th><strong>Identification</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer Name:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer Address:</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Identification</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Working Pressure:</td>
<td>MPa</td>
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<tr>
<td>Type:</td>
<td></td>
</tr>
<tr>
<td>Diameter *¹:</td>
<td>mm</td>
</tr>
<tr>
<td>Length *¹:</td>
<td>mm</td>
</tr>
<tr>
<td>Internal Volume:</td>
<td>litres</td>
</tr>
<tr>
<td>Empty Weight:</td>
<td>kg</td>
</tr>
<tr>
<td>Container Threads:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Service Life</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Service Life:</td>
<td>years</td>
</tr>
<tr>
<td>Maximum Number Of Filling Cycles:</td>
<td>cycles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Fire Protection System</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD Manufacturer:</td>
<td></td>
</tr>
<tr>
<td>PRD Identification:</td>
<td></td>
</tr>
<tr>
<td>PRD Drawing Number(s):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Support Method</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Method:</td>
<td>Neck/Cylinder Mounting *²</td>
</tr>
<tr>
<td>Support Drawing Number(s):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Protective Coatings</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Purpose Of Protection:</td>
<td></td>
</tr>
<tr>
<td>Protective Coating Drawing Number(s):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Design Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Drawing Numbers:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Corrosion Inhibitor</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Corrosion Inhibitor used:</td>
<td>Yes/No *²</td>
</tr>
<tr>
<td>Corrosion Inhibitor Manufacturer:</td>
<td></td>
</tr>
<tr>
<td>Corrosion Inhibitor Identification:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Container</th>
<th><strong>Additional Information</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The Manufacturer hereby states that the Container design is suitable for use during the specified Service Life in the service conditions defined in Paragraph 2.4 of this Regulation.</td>
<td></td>
</tr>
<tr>
<td><strong>Manufacturer:</strong></td>
<td></td>
</tr>
<tr>
<td>Name, position and signature:</td>
<td></td>
</tr>
<tr>
<td>Place, Date:</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** *¹ - May be replaced by other dimensions defining the shape of the Container  
*² – Delete as appropriate
<table>
<thead>
<tr>
<th>Material Specification</th>
<th>Applicable to Material</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Aluminium Alloy</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Plastic Liner</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Fibre</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Resin</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Coating</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Material Manufacturer**

**Type of Material**

**Material Identification**

**Heat Treatment Definition**

**Chemical Composition**

**Cold- or Cryoforming Procedure**

**Welding Procedure Definition**

<table>
<thead>
<tr>
<th>Test Data</th>
<th>Specified Material Value</th>
<th>Test Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2</strong> Tensile Test</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>3</strong> Charpy Impact Test</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>4</strong> Bend Test</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>5</strong> Macroscopic Examination</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>6</strong> Corrosion Test</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>7</strong> Sustained Load Cracking Test</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>B2</strong> Softening/Melting Temperature</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>B3</strong> Glass Transition Temperature, TG</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>B4</strong> Resin Shear Strength, ILSS</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>B5</strong> Coating Test</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>26</strong> Hydrogen Compatibility Test</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Manufacturer:**

Name, position and signature:

Place, Date:

**Technical Service:**

Inspector’s signature:

Place, Date:
Notes:

*1 – For Containers with welded Liners only.

*2 –
   i) For steel Containers or Liners refer to Paragraph 10.2 of ISO 9809-1 or Paragraph 10.2 of ISO 9809-2 as appropriate,
   ii) For stainless steel Containers or Liners refer to Paragraph 7.1.2.1 of EN 1964-3,
   iii) For welded stainless steel Liners refer to Paragraph 8.4 of EN 13322-2.
   iv) For aluminium alloy Containers or Liners refer to Paragraph 10.2 of ISO 7866.
   v) For welded aluminium alloy Liners refer to Paragraphs 7.2.3 and 7.2.4 of EN 12862.
   vi) For non-metallic Liners refer to Paragraph B1 of this Annex.

*3 –
   i) For steel Containers or Liners refer to Paragraph 10.4 of ISO 9809-1 or Paragraph 10.4 of ISO 9809-2 as appropriate,
   ii) For stainless steel Containers or Liners refer to Paragraph 7.1.2.4 of EN 1964-3.
   iii) For welded stainless steel Liners refer to Paragraph 8.6 of EN 13322-2.

*4 –
   i) For welded stainless steel Liners refer to Paragraph 8.5 of EN 13322-2.
   ii) For welded aluminium alloy Liners refer to Paragraphs 7.2.5, 7.2.6 and 7.2.7 of EN 12862.

*5 – For welded stainless steel Liners refer to Paragraph 8.7 of EN 13322-2.

*6 –
   i) For aluminium alloy Containers or Liners refer to Annex A of ISO 7866,
   ii) For welded aluminium alloy Liners refer to Annex A of EN 12862.

*7 –
   i) For aluminium alloy Containers or Liners refer to Annex B of ISO 7866, but excluding the second paragraph of Clause B.2,
   ii) For welded aluminium alloy Liners refer to Annex B of EN 12862, but excluding Paragraph B.2.2.

*8 –
   i) This test is not required for:
      a) Steels that conform to Paragraphs 6.3 and 7.2.2 of ISO 9809-1,
      b) Aluminium alloys that conform to Paragraph 6.1 of ISO 7866.
   ii) For other metallic Containers or Liners hydrogen compatibility of the material, including welds, shall be demonstrated in accordance with ISO 11114-1, ISO/DIS 11114-4 or Paragraph B7 of this Annex as appropriate,
   iii) For non-metallic Liners hydrogen compatibility shall be demonstrated.
### Table 7A.4 - Container Specifications And Test Data

<table>
<thead>
<tr>
<th>Test and Annex 7 Reference</th>
<th>Applicable To Container Type</th>
<th>Specified Design Value</th>
<th>Test Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B9 Burst Test</td>
<td></td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B10 Ambient Temperature Pressure Cycling Test</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B11 LBB Performance Test</td>
<td>✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B12 Bonfire Test</td>
<td>✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B13 Penetration Test</td>
<td>✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B14 Chemical Exposure Test</td>
<td>✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B15 Composite Flaw Tolerance Test</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B16 Accelerated Stress Rupture Test</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B17 Extreme Temperature Pressure Cycling Test</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B18 Impact Damage Test</td>
<td>✓ ✓ ✓ ✓</td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B19 Leak Test</td>
<td></td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B20 Permeation Test</td>
<td></td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B21 Boss Torque Test</td>
<td></td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
<tr>
<td>B22 Hydrogen Gas Cycling Test</td>
<td></td>
<td>✓ ✓ ✓ ✓</td>
<td></td>
</tr>
</tbody>
</table>

**Container Identification:**

**Manufacturer:**

Name, position and signature:

Place, Date:

Technical Service:

Inspector’s signature:

Place, Date:

---

**A3.7 STRESS ANALYSIS**

A stress analysis shall be carried out. A table summarising the calculated stresses shall be provided for information purposes only.

**A3.8 MATERIAL REQUIREMENTS**

A3.8.1 General
Materials used shall be suitable for the service conditions specified in Paragraph 2.4 of this Regulation. Incompatible materials shall not be in contact with each other.

A3.8.2 Steel

A3.8.2.1 Steels for Containers and Liners shall conform to the material requirements of Paragraphs 6.1 to 6.4 of ISO 9809-1 or Paragraphs 6.1 to 6.3 of ISO 9809-2 as appropriate.

A3.8.2.2 Stainless steels for Containers and Liners shall conform to Paragraphs 4.1 to 4.4 of EN 1964-3.

A3.8.2.3 Welded stainless steels for Liners of Type 3 Containers shall conform to Paragraphs 4.1 to 4.3 of EN 13322-2 as appropriate.

A3.8.3 Aluminium Alloy

A3.8.3.1 Aluminium alloys for Containers and Liners shall conform to the material requirements of Paragraphs 6.1 and 6.2 of ISO 7866.

A3.8.3.2 Welded aluminium alloys for Liners of Type 3 Containers shall conform to Paragraphs 4.2 and 4.3 of EN 12862.

A3.8.4 Plastic Liner Materials

The material for plastic Liners may be thermosetting or thermoplastic.

A3.8.5 Fibres

The Container Manufacturer shall keep on file for the intended life of the Container design the published specifications for composite materials including principal test results, i.e. tensile test, the material Manufacturer’s recommendations for storage, conditions and shelf life.

The Container Manufacturer shall keep on file, for the intended life of each batch of Containers, the fibre Manufacturer’s certification that each shipment conforms to the Manufacturer’s specifications for the product.

A3.8.6 Resins

The polymeric material for impregnation of the fibres may be thermosetting or thermoplastic resin.

A3.9 BURST PRESSURE RATIOS

The minimum Burst Pressure ratios, i.e. the minimum actual Burst Pressure of the Container divided by its Nominal Working Pressure, shall not be less than the values given in Table 7A.5.

Table 7A.5 - Minimum Burst Pressure Ratios
## Container Type

<table>
<thead>
<tr>
<th>Construction</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
<th>Type 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>All metal</td>
<td>2.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>2.75</td>
<td>(2.50(^{*1}))</td>
<td>3.65</td>
<td>(3.50(^{*1}))</td>
</tr>
<tr>
<td>Aramid</td>
<td>2.35</td>
<td></td>
<td>3.10</td>
<td>(3.00(^{*1}))</td>
</tr>
<tr>
<td>Carbon</td>
<td>2.35</td>
<td>2.35</td>
<td>2.35</td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td>(^{*2})</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

\(^{*1}\) The minimum Burst Pressure ratios may be reduced to the bracketed values, if the calculated stress ratios, i.e. stress in the fibre at the minimum Burst Pressure Ratio times Nominal Working Pressure divided by the stress in the fibre at Nominal Working Pressure, conform to the un-bracketed values. The stress ratio calculations shall:

i) Be based on an analysis method with capability for non-linear materials (special purpose computer program or finite element analysis program),

ii) Include correct modelling of the Elastic-plastic stress-strain curve for the Liner material,

iii) Include correct modelling of mechanical properties of the composite,

iv) Include calculations made at Auto-frettage Pressure, zero pressure after Auto-frettage, Nominal Working Pressure and minimum Burst Pressure,

v) Take into account the pre-stress from winding tension.

\(^{*2}\) For Container designs using hybrid reinforcement, i.e. two or more different structural fibre types, consideration shall be given to the load share between the different fibres based on the different elastic modulii of the fibres. The calculated stress ratios for each individual structural fibre type shall conform to the un-bracketed values. Verification of the stress ratios may also be performed using strain gauges. The minimum Burst Pressure Ratio shall be chosen such that the calculated stress in the structural fibres at the minimum Burst Pressure Ratio times Nominal Working Pressure divided by the calculated stress in the structural fibre at Nominal Working Pressure meets the stress ratio requirements for the fibres used.

### A4 CONTAINER MANUFACTURING REQUIREMENTS

#### A4.1 TYPE 1 CONTAINERS

A forming process shall not be used to close the ends of aluminium alloy Containers. The base ends of steel Containers that have been closed by forming, shall be inspected using NDE or equivalent techniques. Metal shall not be added in the process of closure at the end. Each Container shall be examined before end forming operations for thickness and surface finish.
After end forming, Containers shall be heat treated to the hardness range specified for the design. Localised heat treatment is not permitted.

For Containers subjected to coldforming or cryoforming processes, heat treatment of the preform component is not required. Containers that have been coldformed or cryoformed shall not be subjected to any subsequent heat treatment or to additional heat application, such as welding.

When a neck ring, foot ring or attachments for support are provided, it shall be of material compatible with that of the Container and shall be securely attached by a method other than welding, brazing or soldering.

A4.2 TYPE 2, 3 AND 4 CONTAINERS

A4.2.1 Composite Filament Winding

When Composite Containers are fabricated from a Liner Over-wrapped with continuous filament windings, the filament winding operations shall be computer or mechanically controlled. During winding the principal parameters shall be monitored and kept within specified tolerances, and documented in a winding record. The principal parameters are:

i) Fibre type including tex value and sizing,
ii) Number of fibre tows per bandwidth,
iii) Type of resin and resin components mix ratio,
iv) Manner of impregnation, weight or volume fraction of resin or fibre,
v) Winding program reference and winding angle,
vi) Number of winding rotations hoop,
vii) Number of windings cycles helical (Type 3 and 4 Containers only),
viii) Band width,
ix) Winding tension,
x) Winding speed,
xii) Temperature of the resin.

A4.2.2 Curing Of Thermosetting Resins

After completion of filament winding, thermosetting resins shall be cured by heating using a predetermined and controlled time-temperature profile. The time-temperature history shall be documented during the curing.

The maximum curing time and temperature for Containers with aluminium alloy Liners shall be below the time and temperature that adversely affect the properties of the metal.

For Type 4 Containers the curing temperature for thermosetting resins shall be at least 10 °C below the softening temperature of the plastic Liner.

A4.2.3 Auto-frettage

Auto-frettage, if used, shall be carried out before the hydraulic test. The Auto-frettage Pressure shall be within the limits established by the Manufacturer.

A4.2.4 Metallic Liners
For metallic \textit{Liners} subjected to coldforming or cryoforming processes, heat treatment of the preform component is not required. \textit{Liners} that have been coldformed or cryoformed shall not be subjected to any subsequent heat treatment or to additional heat application, such as welding.

Welding of stainless steel \textit{Liners} shall conform to Paragraphs 6.1, 6.2 and 6.4 of \textit{EN 13322-2}. Welding of aluminium alloy \textit{Liners} shall conform to Paragraphs 4.1.2 and 6.1 of \textit{EN 12862}.

\section*{A4.3 CONTAINER MARKINGS}

On each \textit{Container}, and where applicable the outer surface of a group of permanently encapsulated \textit{Containers}, the \textit{Manufacturer} shall provide clear permanent markings with a font not less than 6 mm high. Marking shall be made either by labels incorporated into resin coatings, adhesive labels, low stress stamps used on the thickened ends of Type 1 and 2 \textit{Containers}, or any combination of the above. Adhesive labels and their application shall be in accordance with \textit{ISO 7225}, or an equivalent standard. Multiple labels are allowed and should be located such that mounting brackets do not obscure them. Every \textit{Container} type approved in accordance with this Regulation shall bear a marking place with the following data clearly legible:

\begin{itemize}
  \item[i)] Name of the \textit{Manufacturer},
  \item[ii)] A unique serial number for every \textit{Container},
  \item[iii)] The marking \textquotedblleft \textit{H} \textsubscript{2} \textit{GAS},\textquotedblright
  \item[iv)] \textit{Nominal Working Pressure} (MPa) at 15\degree C,
  \item[v)] Year and month of manufacture, e.g. 2000/01,
  \item[vi)] Approval mark in accordance with Paragraph 5.4 of this Regulation,
  \item[vii)] The marking \textit{"DO NOT USE AFTER yyyy/mm"} where yyyy/mm is the year and month of manufacture plus the approved \textit{Service Life} of the \textit{Container}. However, yyyy/mm may be based on the date of dispatch of the \textit{Container} from the \textit{Manufacturer}, provided that it has been stored in a dry location without internal pressure.
  \item[viii)] The marking \textit{"Number of Filling Cycles xxxxx"} where xxxxx is the number of \textit{Filling Cycles} in accordance with Paragraph 2.4.6 of this Regulation.
\end{itemize}

\section*{A5 BATCH TEST REQUIREMENTS}

\section*{A5.1 BATCH TEST}

\subsection*{A5.1.1 General}

The \textit{Manufacturer} shall conduct batch testing on \textit{Finished Containers} that are representative of normal production. The \textit{Finished Containers} to be tested shall be randomly selected from each \textit{Batch}. A \textit{Batch} shall not exceed 200 \textit{Finished Containers} plus those \textit{Finished Containers} to be used in destructive tests, or one shift of successive production, whichever is greater.

With reference to \textbf{Table 7A.6}, the following batch tests are required:

\begin{itemize}
  \item[i)] One \textit{Finished Container} shall be subjected to the ambient temperature pressure cycle test at the frequency given in Paragraph A5.1.2 of this Annex,
\end{itemize}
ii) One Finished Container shall be subjected to the burst test. If a Finished Container passes the ambient temperature pressure cycle test the same Container may be subjected to the burst test,

iii) One Finished Container, Liner or heat-treated test sample that is representative of Finished Containers or Liners, shall be subjected to the other tests specified in Table 7A.6 of this Annex,

iv) If an exterior environmental protective coating is used, e.g. organic coating/paint, one Finished Container or test sample that is representative of the Batch shall be subjected to the coating batch test.

If more Containers than required are subjected to the tests, all results shall be documented.

All Containers represented by a batch test that fail to meet the specified requirements shall follow the procedures specified in Paragraph A5.2 of this Annex.
### Table 7A.6 - Batch Tests

<table>
<thead>
<tr>
<th>Test and Annex Reference</th>
<th>Applicable To Container Type</th>
<th>Specified Design Value</th>
<th>Test Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>*1 Tensile Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*2 Charpy Impact Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*3 Bend Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>*4 Macrophscopic Examination</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B2 Softening/Melting Temp. Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B6 Coating Batch Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B9 Burst Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B10 Ambient Temperature Pressure Cycle Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B19 Leak Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>B21 Boss Torque Test</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Notes:**

*1 _

i) For steel Containers or Liners refer to Paragraph 10.2 of ISO 9809-1 or Paragraph 10.2 of ISO 9809-2 as appropriate,
ii) For stainless steel Containers or Liners refer to Paragraph 7.1.2.1 of EN 1964-3,
iii) For welded stainless steel Liners refer to Paragraph 8.4 of EN 13322-2.
iv) For aluminium alloy Containers or Liners refer to Paragraph 10.2 of ISO 7866,
v) For welded aluminium alloy Liners refer to Paragraphs 7.2.3 and 7.2.4 of EN 12862,
vi) For non-metallic Liners refer to Paragraph B1 of this Annex.

*2 _

i) For steel Containers or Liners refer to Paragraph 10.4 of ISO 9809-1 or Paragraph 10.4 of ISO 9809-2 as appropriate,
ii) For stainless steel Containers or Liners refer to Paragraph 7.1.2.4 of EN 1964-3,
iii) For welded stainless steel Liners refer to Paragraph 8.6 of EN 13322-2.

*3 _

i) For welded stainless steel Liners refer to Paragraph 8.5 of EN 13322-2,
ii) For welded aluminium alloy Liners refer to Paragraphs 7.2.5, 7.2.6 and 7.2.7 of EN 12862.

*4 _

For welded stainless steel Liners refer to Paragraph 8.7 of EN 13322-2.

*5 _

Test on Liner material.

*6 _

The following test sequence shall be used for Container Type 4: Boss Torque Test (B21), followed by an Ambient Temperature Pressure Cycling Test (B10), followed by a Leak Test (B19).
A5.1.2 Frequency Of Ambient Temperature Pressure Cycling Test

*Finished Containers* shall be subjected to the ambient temperature pressure cycling test at a test frequency defined as follows:

i) One *Container* from each *Batch* shall be pressure cycled for 3.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation,

ii) If on 10 sequential production *Batches* of a design family, i.e. similar materials and processes, none of the pressure cycled *Containers* in i) above should leak or rupture within 4.5 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation, then the pressure cycle test can be reduced to one *Container* from every 5 *Batches* of production with the Container selected from the first of the 5 batches,

iii) If on 10 sequential production *Batches* of a design family, none of the pressure cycled *Containers* in i) above should leak or rupture within 6.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation, then the pressure cycle test can be reduced to one *Container* from every 10 *Batches* of production with the Container selected from the first of the 10 batches,

iv) Should more than 3 months have expired since the last *Batch* of production, then a *Container* from the next *Batch* of production shall be pressure cycle tested in order to maintain the reduced frequency of batch testing in ii) or iii) above,

v) Should any reduced frequency pressure cycle test *Container* in ii) or iii) above fail to meet 3.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation, then the batch pressure cycle test frequency in i) shall be reintroduced for at least 10 production *Batches* in order to re-establish the reduced frequency of batch pressure cycle testing in ii) or iii) above,

vi) Should any *Container* in i), ii) or iii) above fail within 3.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation, then the cause of failure shall be determined and corrected following the procedures in Paragraph A5.2 of this Annex. The pressure cycle test shall then be repeated on an additional three *Containers* from that *Batch*. Should any of the three additional *Containers* fail to meet 3.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation, the *Batch* shall be rejected. The *Manufacturer* shall demonstrate that *Containers* produced since the last successful batch test meets all batch test requirements.

A5.2 FAILURE TO MEET TEST REQUIREMENTS

In the event of failure to meet the test requirements, retesting or reheat treatment and retesting shall be carried out as follows:

i) 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,

ii) If the test has been carried out in a satisfactory manner, the cause of the test failure shall be identified.
If the failure is considered to be due to the heat treatment applied, the Manufacturer may subject all the Containers of that Batch to a further heat treatment.

If the failure is not due to the heat treatment applied, all the identified defective Containers shall be rejected or repaired by an approved method. The non-rejected Containers shall then be considered as a new Batch.

In both cases all the relevant prototype or batch tests needed to prove the acceptability of the new Batch shall be repeated. If one or more tests prove even partially unsatisfactory, all Containers of the Batch shall be rejected.

A6 PRODUCTION EXAMINATION AND TEST REQUIREMENTS

Production examination and tests shall be carried out on all Containers during manufacture and after completion, as follows:

i) Verification that the principal dimensions and mass of the Finished Container and of any Liner and Over-wrap are within design tolerances,

ii) Verification of compliance with principal manufacturing parameters, in accordance with Paragraph A3.6 of this Annex, including examination of any specified surface finish with special attention to deep drawn surfaces and folds or laps in the neck or shoulder of forged or spun end enclosures or openings,

iii) For metallic Containers and Liners, NDE in accordance with Annex B of ISO 9803 or Annex C of EN 1964-3 or Annex B of EN 13322-2 as appropriate, or a demonstrated equivalent method capable of detecting the maximum defect size allowed, to verify that the maximum defect size does not exceed the size specified in the design as determined below.

In addition welded stainless steel Liners shall also be examined in accordance with Paragraph 6.8.2 of EN 13322-2, and welded aluminium alloy Liners shall be examined in accordance with Paragraphs 6.2.1 (second paragraph), and 6.2.3 of EN 12862.

The design of Type 1, 2 and 3 Containers shall identify the maximum allowable defect size at any location in the metal Container or Liner that will not grow to a critical size within either the specified retest period or Service Life if no retest is specified. The critical defect size is defined as the limiting through-wall (Container or Liner) thickness defect that would allow stored gas to be discharged without rupturing the Container. Defect sizes for the rejection criteria for ultrasonic scanning or equivalent, shall be smaller than the maximum allowable defect sizes. For Type 2 and 3 Containers, it shall be assumed that there is no damage to non-metallic materials due to any time-dependent mechanisms. The allowable defect size for NDE shall be determined by an appropriate method.

iv) Hardness test for metallic Containers and Liners in accordance with Paragraph B8 of this Annex and fulfil the requirements therein,

v) Hydraulic test, in accordance with Paragraph B23 of this Annex and fulfil the requirements therein,

vi) Leak test for Type 4 Containers, in accordance with Paragraph B19 of this Annex and fulfil the requirements therein,

vii) Verification of markings, in accordance with Paragraph A4.3 of this Annex.

A summary of the required production examination and tests for each Container is provided in Table 7A.7.
Table 7A.7 - Production Examination And Tests

<table>
<thead>
<tr>
<th>Production Examination And Tests &amp; Annex 7 Reference</th>
<th>Applicable To Container Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Principal Design Dimensions</td>
<td>✓</td>
</tr>
<tr>
<td>A3.6 Principal Manufacturing Parameters</td>
<td>✓</td>
</tr>
<tr>
<td>NDE</td>
<td>✓</td>
</tr>
<tr>
<td>B8 Hardness Test</td>
<td>✓</td>
</tr>
<tr>
<td>B19 Leak Test</td>
<td>✓</td>
</tr>
<tr>
<td>B23 Hydraulic Test</td>
<td>✓</td>
</tr>
<tr>
<td>A4.3 Markings</td>
<td>✓</td>
</tr>
</tbody>
</table>

Note:

*1 - Test on metallic Liner

A7 MODIFICATIONS

Modifications may be approved by the reduced test programme specified in Table 7A.8. Any major changes that are not covered by Table 7A.8 shall be subjected to full approval testing.
<table>
<thead>
<tr>
<th>Table 7A.8: Approval Testing Of Modifications</th>
<th>Type Of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>B7</td>
</tr>
<tr>
<td>Fibre Manufacturer</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Metallic Container Or Liner Material</td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Plastic Liner Material</td>
<td>4</td>
</tr>
<tr>
<td>Fibre Material</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Resin Material</td>
<td>4</td>
</tr>
<tr>
<td>Diameter Change ≤20%</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Diameter Change &gt;20%</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Length Change ≤50%</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Length Change &gt; 50%</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Nominal Working Pressure Change ≤20% *1</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Nominal Working Pressure Change &gt;20% *1</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Dome Shape</td>
<td>1, 2, 3, 4</td>
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<tr>
<td>Opening Size</td>
<td>1, 2, 3, 4</td>
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<tr>
<td>Coating Change</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>End Boss Design</td>
<td>4</td>
</tr>
<tr>
<td>Change In Manufacturing Process*2</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Fire Protection System</td>
<td>1, 2, 3, 4</td>
</tr>
</tbody>
</table>

Notes: For example: 2, 3 indicates that a test is required for Type 2 and 3 Containers only

*1 - Only when thickness change is proportional to diameter or pressure change

*2 - A hydrogen cycle test is not required if the stresses in the neck are equal to the original or reduced by the design change (e.g. reducing the diameter of internal threads, or changing the boss length), the liner to boss interface is not affected, and the original materials are used for boss, liner, and seals.

*3 – Any deviation from the parameters specified in Paragraph A3.6 of this Annex is considered to be a change in manufacturing process.
Annex 7: Part B

APPROVAL TEST PROCEDURES FOR CONTAINERS

TESTS OF CONTAINER MATERIALS

B1 TENSILE TEST

B1.1 Sampling

The test applies to Type 4 Containers only.
The test applies to plastic Liner materials only.
Type approval testing - Number of Liners to be tested: 2

B1.2 Procedure

Mechanical properties for plastic Liner materials shall be tested at -40°C in accordance with ISO 527-2.

B1.3 Requirements

The test results shall be within the Manufacturer's specifications.

B1.4 Results

The tensile yield strength and ultimate elongation of plastic Liner materials shall be presented in a test summary, e.g. Table 7A.3 of this Annex.

B2 SOFTENING TEMPERATURE TEST

B2.1 Sampling

The test applies to Type 4 Containers only.
The test applies to polymeric materials only.
Type approval testing - Number of Liners to be tested: 1
Batch testing - Number of Liners to be tested: 1

B2.2 Procedure

The softening temperature of polymeric materials from finished Liners shall be determined based on the A50 method in ISO 306.

B2.3 Requirement

The softening temperature shall be $\geq 100 \, ^\circ\text{C}$.

B2.4 Results

The softening temperature shall be presented in a test summary, e.g. Table 7A.3 of this Annex.
B3  GLASS TRANSITION TEMPERATURE TEST

B3.1 Sampling

The test applies to Type 2, 3 and 4 Containers.
The test applies to composite resin materials only.
Type approval testing - Number of samples to be tested: 3

B3.2 Procedure

The glass transition temperature of resin materials shall be determined in accordance with ASTM D3418.

B3.3 Requirements

The test results shall be within the Manufacturer's specifications.

B3.4 Results

Final results from the test shall be documented by a test report and presented in a test summary, e.g. Table 7A.3 of this Annex. The glass transition temperature to be presented shall be the minimum measured value.

B4  RESIN SHEAR STRENGTH TEST

B4.1 Sampling

The test applies to Type 2, 3 and 4 Containers.
The test applies to composite resin materials only.
Type approval testing - Number of samples to be tested: 3

B4.2 Procedure

Resin materials shall be tested on a sample coupon representative of the Over-wrap in accordance with ASTM D2344.

B4.3 Requirement

After boiling in water for 24 hours the minimum shear strength of the composite shall be 13.8 MPa.

B4.4 Results

The minimum resin shear strength shall be presented in a test summary, e.g. Table 7A.3 of this Annex.

B5  COATING TEST

B5.1 Sampling

The test applies to all Container Types where exterior environmental protective coating is used, e.g. organic coating/paint.
Type approval testing - Number of samples to be tested: As specified in the appropriate standards.
**B5.2 Procedure and Requirement**

Coatings shall be evaluated using the following test methods:

i) **Adhesion strength** in accordance with ISO 4624, using Method A or B as appropriate. The coating shall exhibit an adhesion rating of 4.

ii) **Flexibility** in accordance with ASTM D522, using Method B with a 12.7 mm mandrel at the specified thickness at -20 °C. Test samples shall be prepared in accordance with ASTM D522. There shall not be any visually apparent cracks.

iii) **Impact resistance** in accordance with ASTM D2794. The coating at room temperature shall pass a forward impact test of 18 J.

iv) **Chemical resistance** in general accordance with ASTM D1308. The test shall be conducted using the Open Spot Test Method and 100 hours exposure to a 30% sulphuric acid solution (battery acid with a specific gravity of 1.219) and 24 hours exposure to a polyalkylene glycol, e.g. brake fluid. There shall be no evidence of lifting, blistering or softening of the coating. The adhesion shall meet a rating of 3 when tested in accordance with ASTM D3359. This test is not necessary if a test is undertaken in accordance with Paragraph B14 of this Annex.

v) **Light and water exposure** in accordance with ASTM G154, using an exposure of 1000 hours. There shall be no evidence of blistering. The adhesion shall meet a rating of 3 when tested in accordance with ISO 4624. The maximum gloss loss allowed is 20%.

vi) **Salt spray exposure** in accordance with ASTM B117, using an exposure of 500 hours. Undercutting shall not exceed 3 mm at the scribe mark. There shall be no evidence of blistering. The adhesion shall meet a rating of 3 when tested in accordance with ASTM D3359.

vii) **Resistance to chipping** at room temperature using the ASTM D3170. The coating shall have a rating of 7A or better, and there shall not be any exposure of the substrate.

**B5.3 Results**

Final results from the test shall be presented in a test summary, e.g. Table 7A.3 of this Annex.

**B6 COATING BATCH TEST**

**B6.1 Sampling**

The test applies to all Container Types where exterior environmental protective coating is used, e.g. organic coating/paint. Batch testing - Number of Containers/samples to be tested per Batch: In accordance with Paragraph A5.1 of this Annex.

**B6.2 Procedure and Requirement**

Coatings shall be evaluated using the following test methods:

i) **Coating thickness measurement** in accordance with ISO 2808. The thickness shall meet the design requirements.

ii) **Adhesion strength** in accordance with ISO 4624, using Method A or B as appropriate. The coating shall exhibit an adhesion rating of 4.

**B6.3 Results**
Final results from the test shall be presented in a test summary, e.g. Table 7A.3 of this Annex.

The Manufacturer shall keep the coating thickness and adhesion strength values on file throughout the Service Life of the Container.

**B7 HYDROGEN COMPATIBILITY TEST**

**B7.1 Sampling**

The test applies to Type 1, 2 and 3 Containers.

Type approval testing - Number of Containers or Liners to be tested: 3

**B7.2 Procedure**

Special consideration shall be given to safety when conducting this test.

At ambient temperature use hydrogen to pressure cycle for 3.0 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation, either:

i) The Container between $\leq 2.0$ MPa and $\geq 1.25$ times the Nominal Working Pressure,

or

ii) The Liner between the pressure levels that will provide an equivalent Liner wall stress as would be present at $\leq 2.0$ MPa and $\geq 1.25$ times the Nominal Working Pressure for the Container.

**B7.3 Requirement**

The Containers or Liners shall not fail before reaching 3.0 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation.

**B7.4 Results**

Final results from the test shall be documented by a test report and presented in a test summary, e.g. Table 7A.3 of this Annex.

The Manufacturer shall keep the results on file throughout the Service Life of the Container.

**B8 HARDNESS TEST**

**B8.1 Sampling**

The test applies to all Containers and Liners of Type 1, 2 and 3 Containers. The test applies to metallic materials only. Production testing - Number of Containers or Liners to be tested: All.

The test shall be carried out after the final heat treatment.
B8.2 Procedure

A hardness test shall be carried out on the parallel wall at the centre and at one of the domed ends of each Container or Liner in accordance with ISO 6506-1.

B8.3 Requirement

The hardness value shall be in the range specified for the design.

B8.4 Results

The hardness value shall be presented in a test summary, e.g. Table 7A.3 of this Annex.

The Manufacturer shall keep the results on file throughout the Service Life of the Container.

TESTS OF FINISHED CONTAINERS

B9 BURST TEST

B9.1 Sampling

The test applies to all Container Types.

Type approval testing - Number of Finished Containers to be tested: 3

Type approval testing - Number of Liners to be tested: 1 (Additional test for Type 2 Containers only)

Batch testing - Number of Finished Containers to be tested per Batch: In accordance with Paragraph A5.1 of this Annex.

B9.2 Procedure

The Container shall be hydraulically burst tested at ambient temperature using the following procedure:

The rate of pressurisation shall be ≤ 1.4 MPa/s for pressures higher than 80% of the Nominal Working Pressure times the Burst Pressure ratio stated in Paragraph A3.9 of this Annex. If the rate exceeds 0.35 MPa/s at pressures higher than 80% of the Nominal Working Pressure times the Burst Pressure ratio, then either the Container shall be placed in series between the pressure source and the pressure measurement device, or the time at pressure above the Nominal Working Pressure times the Burst Pressure ratio shall exceed 5 seconds.

B9.3 Requirement

The Burst Pressure of the Container shall exceed the Nominal Working Pressure times the Burst Pressure ratio stated in Paragraph A3.9 of this Annex.

The Burst Pressure of the Liner shall exceed 1.25 times the Nominal Working Pressure.
B9.4 Results

The *Burst Pressure* shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

The *Manufacturer* shall keep the *Burst Pressure* value on file throughout the *Service Life* of the *Container*.

**B10 AMBIENT TEMPERATURE PRESSURE CYCLING TEST**

**B10.1 Sampling**

The test applies to all *Container* Types.

Type approval testing - Number of *Finished Containers* to be tested: 2

Batch testing - Number of *Finished Containers* to be tested per *Batch*: In accordance with Paragraph A5.1 of this Annex.

**B10.2 Procedure**

Pressure cycling shall be performed at ambient temperature in accordance with the following procedure:

i) Fill the *Container* to be tested with a non-corrosive fluid such as oil, inhibited water or glycol.

ii) Pressure cycle for 3.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation, between \( \leq 2.0 \) MPa and \( \geq 1.25 \) times *Nominal Working Pressure* at a rate not exceeding 10 cycles per minute.

For type approval, *Containers* shall be cycled until failure occurs or up to 9 times the number of *Filling Cycles*.

For batch testing, *Containers* shall be destroyed either by continuing the cycling until failure occurs or in accordance with the burst testing procedure of Paragraph B9.2 of this Annex. For batch testing of Type 4 *Containers*, the test sequence given in Note *6* to Table 7A.6 to this Annex shall be followed before destroying the Container.

**B10.3 Requirement**

The *Containers* shall not fail before reaching 3.0 times the number of *Filling Cycles* in accordance with Paragraph 2.4.6 of this Regulation. For type approval, the *Containers* shall either reach 9.0 times the number of *Filling Cycles* without failure, in which case the LBB test in Paragraph B19 of this Annex is not required, or they shall fail by leakage and not by rupture.

**B10.4 Results**

The number of cycles to failure, along with the location and description of the failure initiation shall be documented and presented in a test summary, e.g. Table 7A.4 of this Annex.

The *Manufacturer* shall keep the results on file throughout the *Service Life* of the *Container*.

**B11 LEAK-BEFORE-BREAK (LBB) PERFORMANCE TEST**
B11.1 Sampling

The test applies to all Container Types. The test is not required if the Container design is already proven to exceed 9.0 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation, when tested in accordance with Paragraph B10 of this Annex.

Type approval testing - Number of Finished Containers to be tested: 3

B11.2 Procedure

The Container shall be tested using the following procedure:

i) Fill the Container to be tested with a non-corrosive fluid such as oil, inhibited water or glycol,

ii) Pressure cycle the Container between ≤ 2.0 MPa and ≥ 1.5 times Nominal Working Pressure at a rate of ≤ 10 cycles per minute to 3.0 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation.

B11.3 Requirement

The Containers tested shall either fail by leakage or shall exceed 3.0 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation without failure.

B11.4 Results

The number of cycles to failure, along with the location and description of the failure initiation, shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B12 BONFIRE TEST

B12.1 Sampling

The test applies to all Container Types.

Type approval testing - Number of Finished Containers to be tested: Minimum 1

B12.2 Procedure

Special consideration shall be given to safety when conducting this test.

The Container shall be pressurised to Nominal Working Pressure with hydrogen or a gas with a higher thermal pressure build up. The pressurised Container shall be tested as follows:

i) Place the Container in a horizontal position approximately 100 mm above a uniform fire source with a length of 1.65 m. The arrangement of the fire shall be recorded in sufficient detail to ensure the rate of heat input to the Container is reproducible. Any failure or inconsistency of the fire source during a test shall invalidate the result,

ii) If the Container is ≤ 1.65 m, it shall be positioned centrically above the fire source,

iii) If the Container is > 1.65 m and it is fitted with a Pressure Relief Device at only one end, the fire source shall commence at the opposite end,

iv) If the Container is > 1.65 m and it is fitted with Pressure Relief Devices at more than one location along its length, the centre of the fire source shall be centred.
midway between those Pressure Relief Devices that are separated by the greatest horizontal distance,

v) If the Container is > 1.65 m and it is additionally protected by thermal insulation, 2 fire tests shall be performed at Nominal Working Pressure. The Container shall be positioned centrically above the fire source in one test, while the fire shall commence at one of the Container ends in the other,

vi) Metallic shielding shall be used to prevent direct flame impingement on Container valves, Fittings, or Pressure Relief Devices. The metallic shielding shall not be in direct contact with the Pressure Relief Devices. Any failure during the test of a valve, Fitting or tubing that is not part of the intended protection system for the design shall invalidate the result,

vii) Surface temperatures shall be monitored by at least three thermocouples located along the bottom of the Container and spaced not more than 0.75 m apart. Metallic shielding shall be used to prevent direct flame impingement on the thermocouples. Alternatively, thermocouples may be inserted into blocks of metal measuring less than 25 mm x 25 mm x 25 mm,

viii) The fire source shall provide direct flame impingement on the Container surface across its entire diameter immediately following ignition,

ix) Thermocouple temperatures and the Container pressure shall be recorded at intervals of ≤ 10 seconds during the test,

x) Within 5 minutes of ignition and for the remaining duration of the test the temperature of at least one thermocouple shall indicate at least 590 °C,

B12.3 Requirement

The Container shall only vent through the Pressure Relief Device(s) and shall not rupture.

B12.4 Results

The results shall be presented in a test summary, e.g. Table 7A.4 of this Annex, and shall include the following data for each Container as a minimum:

i) The elapsed time from ignition of the fire to the start of venting through the Pressure Relief Device(s),

ii) The maximum pressure and time of evacuation until a pressure ≤ 1.0 MPa is reached.

B13 PENETRATION TEST

B13.1 Sampling

The test applies to all Container Types.

Type approval testing - Number of Finished Containers to be tested: 1

B13.2 Procedure

The Container, complete with protective coating, shall be tested in the following sequence:

i) Pressurise with compressed gas to Nominal Working Pressure ± 1.0 MPa,

ii) Penetrate at least one sidewall of the Container by an armour piercing bullet with a diameter of 7.62 mm or greater. The projectile shall impact the sidewall at an approximate angle of 45°.

B13.3 Requirement
The Container shall not rupture.

B13.4 Results

The approximate size of the entrance and exit openings and their locations shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B14 CHEMICAL EXPOSURE TEST

B14.1 Sampling

The test applies to Type 2, 3 and 4 Containers. Type approval testing - Number of Finished Containers to be tested: 1

B14.2 Procedure

The Container, including coating if applicable, shall be tested in the following sequence:

i) The upper section of the Container shall be divided into five distinct areas and marked for pendulum impact preconditioning and fluid exposure. The five areas shall each be nominally 100 mm in diameter. The five areas do not need to be oriented along a single line, but shall not overlap,

ii) The approximate centre of each of the five areas shall be preconditioned by the impact of a pendulum body. The steel impact body of the pendulum shall have the shape of a pyramid with equilateral triangle faces and a square base, the summit and the edges being rounded to a radius of 3 mm. The centre of percussion of the pendulum shall coincide with the centre of gravity of the pyramid; its distance from the axis of rotation of the pendulum being 1 m and the total mass of the pendulum referred to its centre of percussion shall be 15 kg. The energy of the pendulum at the moment of impact shall not be less than 30J, and as close to that value as possible. During pendulum impact, the Container shall be held in position by the end bosses or by the intended mounting brackets. The Container shall be unpressurised during preconditioning,

iii) Each of the 5 preconditioned areas shall be exposed to one of five solutions. The five solutions are:
   a) Sulphuric acid - 19% solution by volume in water,
   b) Sodium hydroxide - 25% solution by weight in water,
   c) Methanol/gasoline - 5/95 % concentration,
   d) Ammonium nitrate - 28% solution by weight in water,
   e) Windshield washer fluid (50% by volume solution of methyl alcohol and water).

iv) During the exposure, orientate the Container with the fluid exposure areas uppermost. Place a pad of glass wool approximately 0.5 mm thick and 100 mm in diameter on each of the five preconditioned exposure areas. Apply an amount of the test fluid to the glass wool sufficient to ensure that the pad is wetted evenly across its surface and through its thickness for the duration of the test,

v) Pressure cycle between ≤ 2MPa and ≥ 1.25 times Nominal Working Pressure for the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation, at a maximum pressurisation rate of 2.75 MPa/s,
vi) Pressurise to 1.25 times Nominal Working Pressure and hold at that pressure for a minimum of 24 hours until the elapsed exposure time (pressure cycling and pressure hold) to the environmental fluids equals at least 48 hours,

vii) Burst Test in accordance with Paragraph B9.2 of this Annex.

B14.3 Requirement

The Container shall achieve a Burst Pressure of ≥ 1.8 times Nominal Working Pressure.

B14.4 Results

The Burst Pressure shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B15 COMPOSITE FLAW TOLERANCE TEST

B15.1 Sampling

The test applies to Type 2, 3 and 4 Containers.

Type approval testing - Number of Finished Containers to be tested: 1

B15.2 Procedure

The Container, complete with protective coating, shall be tested in the following sequence:

i) Flaws in the longitudinal direction shall be cut into the Over-wrap. The flaws shall be greater than the visual inspection limits as specified by the Manufacturer, and at least the following flaws shall be cut in the longitudinal direction into the Container sidewall:
   a) 25mm long by 1.25mm deep,
   b) 200mm long by 0.75mm deep.

ii) Pressure cycle the flawed Container between ≤ 2.0 MPa and ≥ 1.25 times Nominal Working Pressure at ambient temperature for 3.0 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation.

B15.3 Requirement

The Container shall not leak or rupture within 0.6 times the number of Filling Cycles in accordance with Paragraph 2.4.6 of this Regulation, but may fail by leakage during the remaining test cycles.

B15.4 Results

The number of cycles to failure, along with the location and description of the failure initiation shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B16 ACCELERATED STRESS RUPTURE TEST

B16.1 Sampling

The test applies to Type 2, 3 and 4 Containers.

Type approval testing - Number of Finished Containers to be tested: 1
B16.2 Procedure

The Container, free of any protective coating, shall be tested in the following sequence:
   i) Pressurise to 1.25 times Nominal Working Pressure for 1000 hours at 85 °C,
   ii) Burst Test in accordance with Paragraph B9.2 of this Annex.

B16.3 Requirement

The Container shall achieve a Burst Pressure of ≥ 0.85 times the Nominal Working Pressure times the Burst Pressure ratio given in Paragraph A3.9 of this Annex.

B16.4 Results

The Burst Pressure shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B17 EXTREME TEMPERATURE PRESSURE CYCLING TEST

B17.1 Sampling

The test applies to Type 2, 3 and 4 Containers.
Type approval testing - Number of Finished Containers to be tested: 1

B17.2 Procedure

The Containers, with the composite wrapping free of any protective coating, shall be hydrostatically cycle tested in the following sequence:
   i) Condition for 48 hours with a temperature ≥ 85 °C and a relative humidity ≥ 95%,
   ii) Pressure cycle between ≤ 2.0 MPa and ≥ 1.25 times Nominal Working Pressure at a temperature ≥ 85 °C and a relative humidity ≥ 95%, for 1.5 times the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation,
   iii) Stabilise at ambient conditions,
   iv) Condition the Container and test fluid to a temperature ≤ -40 °C as measured on the Container surface and in the fluid,
   v) Pressure cycle between ≤ 2.0 MPa and ≥ Nominal Working Pressure at ≤ -40 °C, for 1.5 times the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation,
   vi) Leak Test*1 in accordance with Paragraph B19 of this Annex,
   vii) Burst Test in accordance with Paragraph B9.2 of this Annex.

Note: *1 - Applies to Type 4 Containers only.

B17.3 Requirement

The Containers shall be cycle tested without showing evidence of rupture, leakage, or fibre unravelling.

Type 4 Containers shall meet the leak test requirements.

The Containers shall not burst at less than 85% of the Nominal Working Pressure times the Burst Pressure ratio given in Paragraph A3.9 of this Annex.
B17.4 Results

The Burst Pressure shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B18 IMPACT DAMAGE TEST

B18.1 Sampling

The test applies to Type 3 and 4 Containers. Type approval testing - Number of Finished Containers to be tested: Minimum 1 (All impact tests may be performed on one Container, or individual impacts on a maximum of 3 Containers).

B18.2 Procedure

The drop tests shall be performed at ambient temperature without internal pressurisation or attached valves. A plug may be inserted in the threaded ports to prevent damage to the threads and seal surfaces.

The surface onto which the Container is dropped shall be a smooth, horizontal concrete pad or similar rigid floor.

The Container shall be tested in the following sequence:

i) Drop once from a horizontal position with the bottom 1.8 m above the ground,

ii) Drop once onto each end of the Container from a vertical position with a potential energy ≥ 488 J, but in no case shall the bottom end be more than 1.8 m above the ground,

iii) Drop once at a 45° angle, and then for non-symmetrical or non-cylindrical Containers rotate the Container through 90° along its longitudinal axis and drop again at a 45° angle, with its centre of gravity 1.8 m above the ground. However, if the bottom is closer to the ground than 0.6 m, the drop angle shall be changed to maintain a minimum height of 0.6 m and the centre of gravity 1.8 m above the ground.

iv) No attempt shall be made to prevent bouncing of the Container, but it may be prevented from falling over during the vertical drop test.

v) Pressure cycle the Container between ≤ 2.0 MPa and ≥ 1.25 times Nominal Working Pressure for three times the number of Filling cycles calculated in accordance with Paragraph 2.4.6 of this Regulation.

B18.3 Requirements

The Container shall not leak or rupture within 0.6 times the number of Filling cycles calculated in accordance with Paragraph 2.4.6 of this Regulation, but may fail by leakage during the remaining test cycles.

B18.4 Results

The number of cycles to failure, along with the location and description of the failure initiation shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B19 LEAK TEST
B19.1 Sampling

The test applies to Type 4 Containers only.
Type approval testing - Number of Finished Containers to be tested: 1
Batch testing - Number of Finished Containers to be tested per Batch: In accordance with Paragraph A5.1 of this Annex.
Production testing - Number of Finished Containers to be tested: All

B19.2 Procedure

The Container shall be thoroughly dried and pressurised to Nominal Working Pressure with Leak Test Gas.

For batch testing, follow the test sequence given in Note *6 to Table 7A.6 to this Annex.

B19.3 Requirement

Any leakage detected through cracks, pores, unbonds or similar defects shall cause the Container to be rejected. Permeation through the wall in accordance with Paragraph B20 of this Annex is not considered to be leakage.

B19.4 Results

The total leakage value shall be presented in a test summary, e.g. Table 7A.4 of this Annex. The leakage rate is applicable to tests carried out with 100% hydrogen only. Leakage rates for other gases or gas mixtures shall be converted to an equivalent leakage rate to that for 100% hydrogen.

The Manufacturer shall keep the total leakage value on file throughout the Service Life of the Container.

B20 PERMEATION TEST

B20.1 Sampling

The test applies to Type 4 Containers only.
Type approval testing - Number of Finished Containers to be tested: 1

B20.2 Procedure

Special consideration shall be given to safety when conducting this test.

The Container shall be tested in the following sequence:

i) Pressurise with hydrogen gas to Nominal Working Pressure,
ii) Place in an enclosed sealed chamber at ambient temperature and monitor for permeation for ≥ 500 hours.

B20.3 Requirement

The steady state permeation rate shall be less than 1.0 $Ncm^3$ per hour of hydrogen per litre internal volume of the Container.

B20.4 Results
The steady state permeation rate shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

**B21 BOSS TORQUE TEST**

**B21.1 Sampling**

The test applies to Type 4 Containers only.
Type approval testing - Number of Finished Containers to be tested: 1
Batch testing - Number of Finished Containers to be tested per Batch: In accordance with Paragraph A5.1 of this Annex.

**B21.2 Procedure**

The Container shall be tested in the following sequence:

i) Restrain the body of the Container against rotation,
ii) Apply a torque of 2 times the valve or Pressure Relief Device installation torque specified by the Manufacturer to each end boss of the Container; first in the direction to tighten the threaded connection, then in the direction to loosen, and finally again in the direction to tighten,

For type approval, the following tests shall also be conducted:

i) Leak Test in accordance with Paragraph B19 of this Annex,
ii) Burst Test in accordance with Paragraphs B9.2 & 9.3 of this Annex.

For batch testing, follow the test sequence given in Note *6 to Table 7A.6 to this Annex.

**B21.3 Requirement**

For type approval, the Container shall meet the leak and burst test requirements.

For batch testing, the Container shall meet the leak test requirements.

**B21.4 Results**

The applied torque, leakage and Burst Pressure shall be presented in a test summary, e.g. Table 7A.4 of this Annex. The leakage rate is applicable to tests carried out with 100% hydrogen only. Leakage rates for other gases or gas mixtures shall be converted to an equivalent leakage rate to that for 100% hydrogen.

The Manufacturer shall keep the results on file throughout the Service Life of the Container.

**B22 HYDROGEN GAS CYCLING TEST**

**B22.1 Sampling**

The test applies to Type 4 Containers only.
Type approval testing - Number of Finished Containers to be tested: 1

**B22.2 Procedure**
Special consideration shall be given to safety when conducting this test.

The Container shall be tested in the following sequence:

i) Use hydrogen gas to pressure cycle the Container between \( \leq 2.0 \text{ MPa} \) and \( \geq \text{Nominal Working Pressure} \) for 1000 cycles. The filling time shall not exceed 5 minutes. Unless otherwise specified by the Manufacturer, temperatures during venting shall not exceed the values specified in Paragraph 2.4.5 of this Regulation.

ii) Leak test in accordance with Paragraph B19 of this Annex,

iii) Section the Container and inspect the Liner and Liner/End boss interface for evidence of any deterioration, such as fatigue cracking or electrostatic discharge.

B22.3 Requirement

The Container shall meet the leak test requirements.

The Liner and Liner/End boss interface shall be free of any deterioration, such as fatigue cracking or electrostatic discharge.

B22.4 Results

The total leakage value shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

B23 HYDRAULIC TEST

B23.1 Sampling

The test applies to all Container Types.

Production testing - Number of Finished Containers to be tested: All

B23.2 Procedure and Requirement

i) The Container shall be pressurised to \( \geq 1.5 \text{ times } \text{Nominal Working Pressure} \). Under no circumstance may the pressure exceed the Auto-frettage Pressure.

ii) The pressure shall be maintained for at least 30 seconds to ensure complete expansion. If the pressure cannot be maintained due to failure of the test apparatus, it is permissible to repeat the test at a pressure increased by 0.7 MPa. Not more than 2 such repeat tests are permitted.

iii) For Type 1, 2 or 3 Containers, the Manufacturer shall define the appropriate limit of permanent volumetric expansion for the test pressure used, but in no case shall the permanent expansion exceed 5% of the total volumetric expansion measured under the test pressure. Permanent expansion is defined as the residual volumetric expansion after the pressure has been released.

iv) For Type 4 Containers, the Manufacturer shall define the appropriate limit of elastic expansion for the test pressure used, but in no case shall the elastic expansion of any Container exceed the average Batch value by more than 10%. Elastic expansion is defined as the total expansion less the permanent expansion (see iii above).

v) Any Container that does not meet the defined expansion limit shall be rejected, but may still be used for batch test purposes.

B23.3 Results
The results shall be presented in a test summary, e.g. Table 7A.4 of this Annex.

The Manufacturer shall keep the results on file throughout the Service Life of the Container.
## Annex 8

REQUIREMENTS AND APPROVAL TEST PROCEDURES FOR SPECIFIC COMPONENTS OTHER THAN CONTAINERS

<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part A</strong></td>
<td>PROVISIONS REGARDING THE APPROVAL OF SPECIFIC COMPONENTS OTHER THAN CONTAINERS</td>
</tr>
<tr>
<td>A1</td>
<td>References</td>
</tr>
<tr>
<td>A2</td>
<td>General Requirements</td>
</tr>
<tr>
<td>A3</td>
<td>Approval Requirements</td>
</tr>
<tr>
<td><strong>Part B</strong></td>
<td>APPROVAL TEST PROCEDURES FOR SPECIFIC COMPONENTS OTHER THAN CONTAINERS</td>
</tr>
<tr>
<td>B1</td>
<td>Hydrogen Compatibility Test</td>
</tr>
<tr>
<td>B2</td>
<td>Ageing Test</td>
</tr>
<tr>
<td>B3</td>
<td>Ozone Compatibility Test</td>
</tr>
<tr>
<td>B4</td>
<td>Corrosion Resistance Test</td>
</tr>
<tr>
<td>B5</td>
<td>Hydraulic Pressure Cycle Test</td>
</tr>
<tr>
<td>B6</td>
<td>Endurance Test</td>
</tr>
<tr>
<td>B7</td>
<td>Internal Leakage Test</td>
</tr>
<tr>
<td>B8</td>
<td>External Leakage Test</td>
</tr>
</tbody>
</table>
Annex 8: Part A

PROVISIONS REGARDING THE APPROVAL OF SPECIFIC COMPONENTS OTHER THAN CONTAINERS

A1 REFERENCES

The following standards contain provisions that, through reference in this text, constitute provisions of this Annex. Where standards other than ISO standards are referenced they may be replaced by equivalent national standards.

International Organisation for Standardization (ISO) Standards

ISO 6957: 1988 Copper Alloys - Ammonia Test For Stress Corrosion Resistance

American Society for Testing and Materials (ASTM) Standards

ASTM D572: Test for Accelerated Aging of Vulcanised Rubber by Oxygen Pressure Method

A2 GENERAL REQUIREMENTS

A2.1 Unless otherwise stated in this Annex all tests shall be performed at 20°C ± 5°C.

A2.2 Explosive gas mixtures shall be prevented from developing during the test procedures described in this Annex.

A2.3 The test period for leakage and pressure tests shall be not less than 3 minutes.

A2.4 Unless otherwise stated the applied test pressure is to be measured at the inlet of the component under test.

A3 APPROVAL REQUIREMENTS
A3.1 GENERAL APPROVAL REQUIREMENTS

A3.1.1 In addition to the requirements given below, the Manufacturer shall complete all documents referred to in Part B of this Annex and submit them to the Competent Authority when applying for type approval.

A3.1.2 The Specific Components shall be subjected to the applicable test procedures laid down in Table 8A.1 of this Annex. The tests shall be conducted on Specific Components that are representative of normal production and complete with identification marks.

A3.1.3 The tests specified in Paragraphs B4 to B8 of this Annex shall be conducted on the same samples of Specific Components in the sequence given in Table 8A.1 unless otherwise indicated, e.g. for Fittings the Corrosion Resistance Test (B4) shall be followed by an Endurance Test (B6), and finally by an External leakage Test (B8). If a Specific Component does not contain metallic sub-components the testing shall commence with the first applicable test.

A3.2 SPECIFIC APPROVAL REQUIREMENTS

A3.2.1 Approval for a Flexible Fuel Line shall be given for one of any length with a minimum bending radius specified by the Manufacturer and when assembled with a specific type of Fitting.

A3.2.2 Any reinforcing interlayer of a Flexible Fuel Line shall be protected against corrosion either by a cover or by using a corrosion resistant material for the reinforcement(s), e.g. stainless steel. If a cover is used the formation of bubbles between layers shall be prevented.

A3.2.3 Flexible Fuel Lines shall have an electrical resistance of less than 1 mega-ohm per meter.

A3.2.4 The profile of Receptacles shall comply with ISO 17268.
<table>
<thead>
<tr>
<th>SPECIFIC COMPONENT</th>
<th>TYPE OF TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Material Tests</td>
</tr>
<tr>
<td></td>
<td>B1, B2 &amp; B3</td>
</tr>
<tr>
<td>Automatic Valves</td>
<td>✓</td>
</tr>
<tr>
<td>Fittings</td>
<td>✓</td>
</tr>
<tr>
<td>Flexible Fuel Lines</td>
<td>✓</td>
</tr>
<tr>
<td>Heat Exchangers</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrogen Filters</td>
<td>✓</td>
</tr>
<tr>
<td>Manual Valves</td>
<td>✓</td>
</tr>
<tr>
<td>Non-Return Valves</td>
<td>✓</td>
</tr>
<tr>
<td>Pressure Regulators</td>
<td>✓</td>
</tr>
<tr>
<td>Pressure Relief Devices</td>
<td>✓</td>
</tr>
<tr>
<td>Pressure Relief Valves</td>
<td>✓</td>
</tr>
<tr>
<td>Receptacles</td>
<td>✓</td>
</tr>
<tr>
<td>Removable Storage System Connectors</td>
<td>✓</td>
</tr>
<tr>
<td>Sensors for Hydrogen Systems</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Table 8A.1:** Applicable Test Procedures For Specific Components Other Than Containers

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Annex 8: Part B

APPROVAL TEST PROCEDURES FOR SPECIFIC COMPONENTS OTHER THAN CONTAINERS

MATERIAL TESTS

B1 HYDROGEN COMPATIBILITY TEST

B1.1 Sampling

The test applies to the materials used in a Specific Component where the material is in contact with hydrogen except:

i) Aluminium alloys that conform to Paragraphs 6.1 and 6.2 of ISO 7866,
ii) Steels that conform to Paragraph 6.3 and 7.2.2 of ISO 9809-1.

Number of material samples to be tested: 3

B1.2 Procedure and Requirements

i) For metallic materials other than those stated above hydrogen compatibility shall be demonstrated in accordance with ISO11114-1 or ISO/DIS 11114-4.
ii) Non-metallic materials

Hydrogen compatibility shall be demonstrated.

B1.3 Results

The results of the tests shall be presented in a test summary.

B2 AGEING TEST

B2.1 Sampling

All non-metallic materials used in a Specific Component shall be tested.

Number of material samples to be tested: 3

B2.2 Procedure and Requirements

Special consideration shall be given to safety when conducting this test.

The test shall be undertaken in accordance with ASTM D572. The sample shall be exposed to oxygen at the maximum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation at 2.0 MPa for a period of 96 hours. Either the tensile strength and elongation or the microhardness shall comply with the specifications given by the Manufacturer. No visible cracking of the test samples is allowed.

B2.3 Results

The results of the tests shall be presented in a test summary.

B3 OZONE COMPATIBILITY TEST

B3.1 Sampling
The test applies to elastomer materials where:
  i) A sealing surface is exposed directly to air, e.g. facing seal of a Receptacle,
  ii) Used as a Flexible Fuel Line cover.

Number of material samples to be tested: 3

B3.2 Procedure and Requirements

The test shall be undertaken in accordance with ISO 1431/1.
The test samples shall be stressed to 20 percent elongation and exposed to air at 40°C with an ozone concentration of 0.5 parts per million for a period of 120 hours.

No visible cracking of the test samples is allowed.

B3.3 Results

The results of the tests shall be presented in a test summary.

TESTS OF SPECIFIC COMPONENTS

B4 CORROSION RESISTANCE TEST

B4.1 Sampling

Number of Specific Components to be tested: 3

B4.2 Procedure and Requirements

Test i) Metallic components shall be submitted to a 144 hour salt spray test in accordance with ISO 9227 with all connections closed and shall meet the requirements therein.

Test ii) A copper alloy component shall also be submitted to 24 hours immersion in ammonia in accordance with ISO 6957 with all connections closed and shall meet the requirements therein.

B4.3 Results

The results of the tests shall be presented in a test summary.

B5 HYDRAULIC PRESSURE CYCLE TEST

B5.1 Sampling

Number of Specific Components to be tested: 3

B5.2 Procedure and Requirements

B5.2.1 Pressure Relief Devices
Pressure Relief Devices shall be subjected to 1.5 times the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation at both the minimum and maximum material temperatures in accordance with Paragraph 2.4.5.1 of this Regulation.

The pressure shall periodically change from 2 MPa to 1.25 times Nominal Working Pressure at a rate not exceeding 4 cycles per minute, except when tested at the minimum material temperature when the maximum test pressure shall be Nominal Working Pressure.

If fusible metal is used in a Pressure Relief Device it shall show no visible sign of extrusion.

B5.2.2 Specific Components Other Than Pressure Relief Devices

The Specific Components shall be subjected to 3 times the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation.

The pressure shall periodically change from 2.0 MPa to 1.25 times Nominal Working Pressure for components upstream the First Pressure Regulator, or from 0.1 times MAWP to MAWP for components downstream of the First Pressure Regulator, at a rate not exceeding 4 cycles per minute.

Subsequently the Component shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs B7 and B8 of this Regulation).

B5.3 Results

The results of the tests shall be presented in a test summary.

B6 ENDURANCE TEST

B6.1 Sampling

Number of Specific Components to be tested: 3

B6.2 Procedures And Requirements

B6.2.1 Automatic, Manual & Non-return Valves

The Specific Component shall be tested in accordance with the following procedure:

i) Pressurise the Specific Component with dry air, nitrogen, or hydrogen to Nominal Working Pressure and subject it to 96% of the total number of test cycles in accordance with Table B6.1 of this Annex at 20°C ± 5°C. A complete test cycle shall take place over a period of not less than 10 ± 2 seconds. When in the closed position the downstream pressure of the component under test is allowed to decay to 0.5 times the Nominal Working Pressure of the component. The Specific Component shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs B7 and B8 of this Annex respectively) at this temperature.
ii) The Specific Component shall then be operated through 2% of the total number of test cycles at the minimum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation after 2 hours conditioning at this temperature. The Specific Component shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs B7 and B8 of this Annex respectively) at this temperature.

iii) The Specific Component shall then be operated through 2% of the total number of test cycles at the maximum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation after 2 hours conditioning at this temperature and at 1.25 times Nominal Working Pressure. The Specific Component shall fulfil the requirements of the Internal and External Leakage Tests (Paragraphs B7 and B8 of this Annex respectively) at this temperature.

B6.2.2 Fittings

Fittings shall be subjected to 25 connection/disconnection cycles.

B6.2.3 Flexible Fuel Lines

The length of the flexible part of the Flexible Fuel Line with its Fittings attached, to be used in the following test shall be calculated as follows:

\[ L = 4.142R + 3.57D \]

where:

- \( L \) = Length of the flexible part of the Flexible Fuel Line
- \( R \) = Minimum bending radius specified by the Manufacturer
- \( D \) = Outside diameter of the Flexible Fuel Line

The Flexible Fuel Line shall be bent in the manner depicted in Figure 8B.1 of this Annex and attached to a fixture in that position by the Fittings with which it is to be approved. One end of the Flexible Fuel Line shall be attached to a reciprocating manifold and the other end shall be attached to a stationary manifold connected to a hydraulic supply. The Flexible Fuel Line shall be pressurised quickly by means of a quick opening solenoid valve, such that one cycle consists of holding the pressure at 1.25 times the Nominal Working Pressure for 10 ± 1 seconds (except for Flexible Fuel Lines with a required material temperature of 120°C where the hold pressure shall be 1.37 times Nominal Working Pressure) and then reducing it to less than 0.1 times the Nominal Working Pressure for 5 ± 0.5 seconds. The total number of test cycles shall be equal to 2.0 times the number of Filling Cycles or Duty Cycles as appropriate to the use of the Flexible Fuel Line in accordance with Paragraph 2.4.6 or 2.4.7 of this Regulation as appropriate. 50% of the test cycles shall be performed at the minimum and the remaining 50% at the maximum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation.

Superimposed on the hydraulic pressure cycles is a flexing cycle. The flexing rate shall be 36 ± 2% of the hydraulic pressure cycling rate. This assures that the Flexible Fuel Line is in a different configuration on each succeeding pressure cycle impulse. The test fixture is shown in Figure 8B.1 of this Annex with the distance A calculated as:

\[ A = 1.75R + D \]
The *Flexible Fuel Line* shall not show any visible signs of damage.

**Figure 8B.1**: Flex-impulse Testing Fixture

### B6.2.4 Pressure Regulators

*Pressure Regulators* shall be tested in accordance with the following procedure:

i) The *Pressure Regulator* shall be connected to a source of *Leak Test Gas* at *Nominal Working Pressure* and cycled through 95% of the number of *Duty Cycles* calculated in accordance with Paragraph 2.4.7 of this Regulation. One cycle shall consist of flow until stable outlet pressure has been attained, after which the gas flow shall be shutoff by a downstream quick closing valve until stable lockup pressure has been achieved. The *Pressure Regulator* shall then fulfill the requirements of the Internal and External Leakage Tests (Paragraphs B7 and B8 of this Annex respectively) conducted at 20°C ± 5°C.

ii) The inlet of the *Pressure Regulator* shall be pressure cycled through 1% of the number of *Duty Cycles* from *Nominal Working Pressure* to 0.5 times the *Nominal Working Pressure* or less. Subsequently the *Pressure Regulator* shall fulfill the requirements of the Internal and External Leakage Tests (B8 and B8) conducted at 20°C ± 5°C.

iii) The cycling procedure in i) above shall be repeated at the maximum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation and at 1.25 times the *Nominal Working Pressure* for 1% of the number of *Duty Cycles*. Subsequently the *Pressure Regulator* shall fulfill the requirements of the Internal and External Leakage Tests (B7 and B8) conducted at the maximum material temperature.

iv) The cycling procedure in ii) above shall be repeated at the maximum material temperature and at 1.25 times the *Nominal Working Pressure* for 1% of the number of *Duty Cycles*. Subsequently the *Pressure Regulator* shall fulfill the requirements of the Internal and External Leakage Tests (B7 and B8) conducted at the maximum material temperature.
v) The cycling procedure in i) above shall be repeated at the minimum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation and at Nominal Working Pressure for 1% of the number of Duty Cycles. Subsequently the Pressure Regulator shall fulfil the requirements of the Internal and External Leakage Tests (B7 and B8) conducted at the minimum material temperature.

vi) The cycling procedure in ii) above shall be repeated at the minimum material temperature and at Nominal Working Pressure for 1% of the number of Duty Cycles. Subsequently the Pressure Regulator shall fulfil the requirements of the Internal and External Leakage Tests (B7 and B8) conducted at the minimum material temperature.

B6.2.5 Pressure Relief Devices

i) Creep Test

Pressure Relief Devices shall be hydrostatically pressurised to 1.25 times Nominal Working Pressure and held for 500 hours at a temperature (Tₐ) calculated from the following equation:

\[ Tₐ = T \left(0.057 \times \log\left(T/T_f\right)\right) \]

where

- \( Tₐ \) = Test temperature, °C
- \( T_f \) = Activation temperature of the Pressure Relief Device, °C
- \( T = 82°C \)
- Log is base 10

Pressure Relief Devices shall not show signs of creep and shall fulfil the requirements of the Internal Leakage Test (Paragraph B7 of this Annex) after being subjected to the above test.

ii) Activation Temperature

Following the Creep Test in i) above, the Pressure Relief Devices shall be pressurised with dry air, nitrogen, or hydrogen to Nominal Working Pressure. Subsequently the Pressure Relief Devices shall be exposed to an increasing temperature cycle starting from ambient temperature with a rate not exceeding 10 °C per minute until the specified activation temperature minus 10 °C is reached and then with a rate of not exceeding 2 °C per minute until the Pressure Relief Devices activate. The activation temperature shall correspond to the melting temperature of the fusible metal specified by the Manufacturer within a range of ± 2 °C. After activation the Pressure Relief Devices shall show no evidence of fragmentation.

B6.2.6 Pressure Relief Valves

Pressurise the Pressure Relief Valve for 25 cycles. A test cycle consists of pressurising the Pressure Relief Valve to the activation pressure causing the Pressure Relief Valve to open and vent. Once the Pressure Relief Valve is venting the inlet pressure shall be reduced causing the Pressure Relief Valve to re-seat. The cycle time shall be a period of 10 ± 2 s. For the final cycle the activation pressure shall be reported and shall correspond to the activation pressure specified by the Manufacturer within a range of ±5%.

B6.2.7 Receptacles
Receptacles shall be submitted to a number of connection/disconnection cycles equal to three times the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation. For each cycle the Receptacle shall be pressurised to 1.25 times the Nominal Working Pressure. Before depressurising, the nozzle shall be rotated by 90°.

B6.2.8 Sensors For Hydrogen Systems

If a sensor is intended to be installed into a Hydrogen Component and is subjected to the same number of Duty Cycles or Filling Cycles, it shall be subjected to the same endurance test as the Hydrogen Component into which it is installed.

B5.2.9 Removable Storage System Connector

A Removable Storage System Connector shall be submitted to a number of connection/disconnection cycles equal to three times the number of Filling Cycles calculated in accordance with Paragraph 2.4.6 of this Regulation. For each cycle the Removable Storage System Connector shall be pressurised to 1.25 times the Nominal Working Pressure. Subsequently the Removable Storage System Connector shall fulfil the requirements of the External Leakage Test (Paragraph B8 of this Annex) when the parts of the Removable Storage System Connector mounted on the vehicle and on the Removable Storage System are separated and also when connected together.

<table>
<thead>
<tr>
<th>SPECIFIC COMPONENT</th>
<th>NO. OF TEST CYCLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Valve</td>
<td>1.5 times the number of Duty Cycles or Filling Cycles in accordance with Paragraph 2.4.6 or 2.4.7 of this Regulation, as appropriate to the use of the valve.</td>
</tr>
<tr>
<td>Manual Valve</td>
<td>100</td>
</tr>
<tr>
<td>Non-return Valve</td>
<td>2.0 times the number of Duty Cycles or Filling Cycles in accordance with Paragraph 2.4.6 or 2.4.7 of this Regulation, as appropriate to the use of the valve.</td>
</tr>
</tbody>
</table>

Table B6.1: Test Cycles For Valves

B6.3 Results

The results of the test shall be presented in a test summary.

B7 INTERNAL LEAKAGE TEST

B7.1 Sampling

Number of Specific Components to be tested: 3
B7.2 Procedure

The *Specific Components* shall be tested using *Leak Test Gas* and shall be pressurised at the inlet of the component when it is in its characteristic closed position and with the corresponding outlet port open.

The *Specific Component* shall be tested at the following conditions:

i) At $20^\circ C \pm 5^\circ C$ and at 0.02 times *Nominal Working Pressure* and at *Nominal Working Pressure*. Where an External Leakage Test (Paragraph B8 of this Annex) is also required at this temperature it may be undertaken before the next stage of this test.

ii) At the minimum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation, after 2 hours conditioning to this temperature and at 0.02 times *Nominal Working Pressure* and at *Nominal Working Pressure*. Where an External Leakage Test (Paragraph B8 of this Annex) is also required at this temperature it may be undertaken before the next stage of this test.

iii) At the maximum material temperature in accordance with Paragraph 2.4.5.1 of this Regulation, after 2 hours conditioning to this temperature and at 0.02 times *Nominal Working Pressure* and 1.25 times *Nominal Working Pressure*, except for components with a required material temperature of $120^\circ C$ where the higher test pressure shall be 1.37 times *Nominal Working Pressure*.

The component shall be observed for leakage with its outlet port open. The leakage can be determined by a flowmeter installed on the inlet side of the component or by another test method, which has been demonstrated to be equivalent.

B7.3 Requirements

When pressurised the *Specific Component* shall stay bubble free for three minutes or shall not leak internally at a rate exceeding $10 \text{ Ncm}^3$ per hour. The permitted leakage rate is applicable to tests with 100% hydrogen only. Permitted leakage rates for other gases or gas mixtures shall be converted to an equivalent leakage rate to that for 100% hydrogen.

B7.4 Results

The results of the test shall be presented in a test summary.

B8 EXTERNAL LEAKAGE TEST

B8.1 Sampling

Number of *Specific Components* to be tested: 3

B8.2 Procedure

The *Specific Components* shall be tested using *Leak Test Gas* at the following conditions:

i) At $20^\circ C \pm 5^\circ C$ and at 0.02 times *Nominal Working Pressure* and at *Nominal Working Pressure*.
ii) At the minimum required material temperature, in accordance with Paragraph 2.4.5.1 of this Regulation, after 2 hours conditioning to this temperature and at 0.02 times Nominal Working Pressure and at Nominal Working Pressure.

iii) At the maximum required material temperature, in accordance with Paragraph 2.4.5.1 of this Regulation, after 2 hours conditioning to this temperature and at 0.02 times Nominal Working Pressure and 1.25 times Nominal Working Pressure, except for components with a required material temperature of 120°C where the higher test pressure shall be 1.37 times Nominal Working Pressure.

For heat exchangers this test shall only be undertaken on the hydrogen circuit.

B8.3 Requirements

Throughout the test the Specific Component shall be free from leakage through stem or body seals or other joints, and shall not show evidence of porosity in casting, demonstrated by a surface active agent without formation of bubbles for 3 minutes or measured with a combined leakage and permeation rate less than 10 Ncm³ per hour (for Flexible Fuel Lines only 10 Ncm³ per hour per meter) or it shall be tested by using a demonstrated equivalent test method. The permitted leakage rate is applicable to tests with 100% hydrogen only. Permitted leakage rates for other gases or gas mixtures shall be converted to an equivalent leakage rate to that for 100% hydrogen.

B8.4 Results

The results of the test shall be presented in a test summary.
Annex 9

SPECIAL REQUIREMENTS TO BE APPLIED TO THE SAFETY ASPECTS OF COMPLEX ELECTRONIC VEHICLE CONTROL SYSTEMS

1 GENERAL

This Annex defines the special requirements for documentation, verification and test with respect to the safety aspects of Complex Electronic Vehicle Control Systems as far as this Regulation is concerned.

2 DOCUMENTATION

2.1 Requirements

The vehicle manufacturer shall provide a documentation package, which gives access to the basic design of “The System” and the means by which it is linked to other vehicle systems or by which it directly controls output variables. The function(s) of “The System” and the Safety Concept, as laid down by the vehicle manufacturer, shall be explained. Documentation shall be brief, yet provide evidence that the design and development has had the benefit of expertise from all the system fields that are involved. For periodic technical inspections, the documentation shall indicate the means by which the current operational status of the system can be checked.

Documentation shall be made available in 2 parts:

i) The formal documentation package for the approval, containing the material listed in Paragraphs 2.2 to 2.4 of this Annex, which shall be supplied to the Technical Service at the time of submission of the type approval application. This will be taken as the basic reference for the verification process set out in Paragraph 3 of this Annex.

ii) Additional material and analysis data which shall be retained by the vehicle manufacturer, but made open for inspection at the time of type approval.

2.2 Description of the Functions of “The System”.

A description shall be provided which gives a simple explanation of all the control functions of “The System” and the methods employed to achieve the objectives, including a statement of the mechanism(s) by which control is exercised including:

i) A list of all input and sensed variables shall be provided and the working range of these defined.

ii) A list of all output variables that are controlled by “The System” shall be provided and an indication given, in each case, of whether the control is direct or via another vehicle system. The Range of Control exercised on each such variable shall be defined.

iii) Limits defining the Boundary of Functional Operation shall be stated where appropriate to system performance.

2.3 System Layout and Schematics

2.3.1 Inventory of Components
A list shall be provided, collating all the *Units* of “The System” and mentioning the other vehicle systems that are needed to achieve the control function in question. An outline schematic showing these *Units* in combination, shall be provided with both the equipment distribution and the interconnections clearly identified.

### 2.3.2 Functions of the *Units*

The function of each *Unit* of “The System” shall be outlined and the signals linking it with other *Units* or with other vehicle systems shall be shown. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

### 2.3.3 Interconnections

A circuit diagram shall show interconnections within “The System” for the electric *Transmission Links*, by a piping diagram for pneumatic or hydraulic *Transmission Links* and by a simplified diagrammatic layout for mechanical *Transmission Links*.

### 2.3.4 Signal Flow and Priorities

There shall be a clear correspondence between these *Transmission Links* and the signals carried between *Units*. Priorities of signals on multiplexed data paths shall be stated, wherever priority may be an issue affecting performance or safety as far as this Regulation is concerned.

### 2.3.5 Identification of *Units*

Each *Unit* shall be clearly and unambiguously marked with the Manufacturer’s identification marking to provide corresponding hardware and documentation association. Where functions are combined within a single *Unit* or indeed within a single computer, but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single identification marking shall be used. The Manufacturer shall, by the use of this identification marking, affirm that the equipment supplied conforms to the corresponding document.

The identification marking defines the hardware and software version and, where the latter changes such as to alter the function of the *Unit*, this identification marking shall also be changed.

### 2.4 Safety Concept Of The Vehicle Manufacturer

#### 2.4.1

The vehicle manufacturer shall provide a statement that affirms that the strategy chosen to achieve “The System” objectives will not, under non-fault conditions prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.

#### 2.4.2

In respect of software employed in “The System”, the outline architecture shall be explained and the design methods and tools used shall be identified. The Manufacturer shall be prepared, if required, to show some evidence of the means by which they determined the
realisation of the system logic, during the design and development process.

2.4.3 The **Manufacturer** shall provide the Technical Service with an explanation of the design provisions built into “The System” so as to generate safe operation under fault conditions. Possible design provisions for failure in “The System” are:

i) Fall-back to operation using a partial system,

ii) Change-over to a separate back-up system,

iii) Removal of the high level function.

For each of the chosen provisions, the driver shall be warned for example by warning signals or message displays. When the system is not deactivated by the driver, e.g. by turning the vehicle activation switch to “off”, or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.

2.4.3.1 If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.

2.4.3.2 If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.

2.4.3.3 If the chosen provision selects the removal of the higher level function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.

2.4.4 The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety. This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations. The chosen analytical approach shall be established and maintained by the vehicle manufacturer and shall be made open for inspection by the Technical Service at the time of the type approval.

2.4.5 The documentation shall itemise the parameters being monitored and shall set out, for each fault condition of the type defined in Paragraph 2.4.3 of this Annex, the warning signal to be given to the driver or to service/technical inspection personnel.

3 VERIFICATION AND TEST
3.1 The functional operation of “The System”, as laid out in the documents required in Paragraph 2 of this Annex shall be tested as follows:

3.1.1 Verification of the Function of “The System”

As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the Manufacturer’s basic benchmark specification unless this is subject to a Specified Performance Test as part of the Approval Procedure of this or another Regulation.

3.1.2 Verification of the Safety Concept of Paragraph 2.4 of this Annex

The reaction of “The System” shall, at the discretion of the Technical Service, be checked under the influence of a failure in any individual Unit by applying corresponding output signals to electrical Units or mechanical elements in order to simulate the effects of internal faults within the Unit.

3.1.3 The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the Safety Concept and execution are confirmed as being adequate.

3.2 The warning signal specified in Paragraph 2.4.3 of this Annex may, in general, be satisfied by one optical signal per complex vehicle system unless any other Regulation applicable to the same equipment specifically requires multiple signals.
Annex 10

PROVISIONS REGARDING HYDROGEN IDENTIFICATION MARKS FOR PUBLIC SERVICE VEHICLES

The sign consists of an adhesive label that shall be weather resistant.

The colour and dimensions of the sticker shall fulfil the following requirements:

Colours:

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>Green</td>
</tr>
<tr>
<td>Border</td>
<td>White</td>
</tr>
<tr>
<td>Letters</td>
<td>White</td>
</tr>
</tbody>
</table>

Either the borders and letters or the background shall be retro-reflective. Colorimetric and photometric properties shall comply with the requirements of clause 11 of ISO 3864-1:2002 (Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs in workplaces and public areas).

Dimensions:

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Border width</td>
<td>5 mm</td>
</tr>
<tr>
<td>Sticker width</td>
<td>125 mm (across flat sides)</td>
</tr>
<tr>
<td>Sticker height</td>
<td>125 mm (across flat sides)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Font size</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Font height</td>
<td>25 mm</td>
</tr>
<tr>
<td>Font thickness</td>
<td>5 mm</td>
</tr>
</tbody>
</table>

The words shall be in upper case characters, centralised to suit the dimensions.