**EUROPEAN INTEGRATED HYDROGEN PROJECT – PHASE II**
**(EIHP2)**
**Contract No. ENK6 – CT2000 - 00442**

# $CGH_2$ REGULATIONS WORKING GROUP

## AGREED CHANGES INCLUDED IN DRAFT ECE $CGH_2$ REGULATIONS (Revision 8 Dated 23.11.01)

# INTRODUCTION

The following modifications were made by the EIHP2 $CGH_2$ Regulations Working Group in response to comments received regarding the draft ECE regulations for the use of compressed gaseous hydrogen in road vehicles (Revision 7, Dated 20.04.00) at working group meetings between 9 October 2001 and 21 November 2001.

The working group meetings included representatives of the following EIHP2 partners:

AB Volvo
DaimlerChrysler
Opel
Raufoss
Vandenborre Technologies

The modifications were integrated into Revision 8, dated 23.11.01 of the EIHP2 proposals for draft ECE regulations for the use of compressed gaseous hydrogen in road vehicles. Minor editorial changes are not included in this document.

Annex 7 of the proposed draft regulation is based on a draft ISO standard and is excessively design orientated for use in a regulation. The annex is to be redrafted to define the appropriate performance requirements necessary for the type approval of compressed gaseous hydrogen containers. The initial draft of the new Annex 7 will be available in March 2002. In the meantime some modifications have been made to the Annex 7 compared with the version found in Revision 7.

# AGREED MODIFICATIONS TO EIHP DRAFT ECE COMPRESSED GASEOUS HYDROGEN ($CGH_2$) REGULATION Version 7 Dated 20.04.00 TO CREATE Version 8 Dated 23.11.01

## Introduction

1. The original wording used by the commenting organisations is provided below.
2. Minor editorial changes have not been included in the comments below.
3. In general the numbering refers to ver.7 of the $CGH_2$ draft, however, some later changes refer to ver.8.

| DRAFT ECE COMPRESSED GASEOUS HYDROGEN ($CGH_2$) REGULATION Version 7 MODIFICATIONS | | |
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| Paragraph | Proposed Modification Based On Original Comment | Remarks |
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| General | Where phrases are defined in Section 2, they should be clearly identified in other parts of the document, i.e. *capitalised italics* | Change where appropriate |
| General | Complete proposals for changes to the service life/fatigue requirements are given at the end of the comments. | See changes at end of comments tables |
| General | Reword references into Chapters, Sections or Paragraphs? | Check all refer to paragraphs |
| General | Delete the words "to/of this Regulation" and "above/below" when referring to various Paragraphs, e.g. "Annex 3 ~~to this regulation~~" and "referred to in Paragraph 3.2 ii) ~~above~~". | Rephrase above/ below to "of this Regulation/Annex" |
| General (or at least Annex 7) | It is a bad mix of numbering (e.g. a) b) …, or i), ii) …) Take for instance A.12 and A.13 in Annex 7. | Change where appropriate |
| 1.1 | Further to the EIHP2 WG4 meeting on 5 July the proposed wording for changes to redefine the scope of the draft CGH2 regulations is as follows:<br><br>"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 auxiliary power unit. The boundary between the Hydrogen System and the Propulsion System or auxiliary power unit is defined as the point(s) at which the Working Pressure decreases to 0.5Mpa or the maximum operating pressure of the Propulsion System or auxiliary power unit, whichever is higher." | Section 1.1 is to be amended as follows:<br>"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 auxiliary power unit." |
| 1.1 | Proposed Modification: | See previous comment. |

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| | 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 auxiliary power unit.<br><br>Comment:<br>• Propulsion System is defined under 2.1.44 as the internal combustion engine or fuel cell system used to propel the vehicle.<br>• See also 2.1.34 | Following changes to be made to 2.1.34:<br>"The boundary between the Hydrogen Conversion System(s) and is defined as the point(s) at which the Working Pressure is higher than the:<br>i) Maximum operating pressure of fuel cell system(s),<br>ii) The inlet pressure of the gas mixer (carburettor or injector(s)) for internal combustion engines or other combustion devices." |
| 1.1 | We agree to the proposal in general. However the mentioned pressure 5MPa (50bar) seems to be very high. Furthermore, it is difficult to determine the appropriate pressure right now.<br>We therefore propose to use following wording:<br>"The boundary between the Propulsion System or auxiliary power unit and the Hydrogen System is defined as the point(s) at which the Working Pressure increases to a higher pressure than the maximum operating pressure of the Propulsion System or auxiliary power unit." | See previous 2 comments |
| 1.2 | Add after motor vehicles "of categories M and N" | |
| 1.3 | Proposed Modification:<br>1.3 Vehicles of categories M and N with regard to the installation of Specific Components for the use of compressed gaseous hydrogen (Part 2 of this Regulation).<br><br>Comment:<br>• See 2.1.1 | |
| 2 | Delete "Standard" from title (as in title for 2.4) | |
| 2.1.1 | Proposed Modification:<br>2.1.1 "Approval of a Vehicle" The approval of a vehicle type ~~of categories M and N~~ with regard to its Hydrogen System installed as original equipment.<br><br>Comment:<br>• The categories of vehicle types the regulation is applicable to have to be determined | |

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| | in the scope | |
| 2.1.2 | The definition should be written more direct regarding Non return Valve/Check valve.<br>Proposal: A valve which is not operated manually. A Non Return valve can not be assumed as a automatic valve.<br>Regarding Non return valve/check valve se comment under 2.1.10 | Changed to:<br>"A valve which is not operated manually. A Non-return Valve is not an Automatic Valve." |
| 2.1.10 | The text in the regulation should use either Non return valve or check valve throughout the whole document. Proposal:<br>Check valve | Use "non-return valve" only as the name makes the function clearer |
| 2.1.12 | A composite container/cylinder is a mix of different materials. A container consisting of a metal liner and a fibre reinforcement is a a composite cylinder. Changing metal to plastic, does not make the container/cylinder more "composite"<br>OXFORD Definition: Composite=(thing) made up of different parts of materials | New definition: "A Container constructed of more than one material." |
| 2.1.14 | Delete "at ambient temperature" from definition of Container. ("within the specified temperature limits"?) | *Container*": Any system 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*. |
| 2.1.15 | This definition is for something that has to do with production of a component, and should be deleted | Reference to "hoop wrapped composite containers" replaced with "Composite Containers." |
| 2.1.16 | Design Pressure. We should be aware that in for instance in R110 the wording Working pressure is used for this pressure. The wording should have been harmonized. Our proposal is to use Design pressure as in this regulation, but modify the definition in line with R110<br>Proposal: "Design pressure" The maximum pressure to which a component is designed to be subjected to and which is basis for determining the strength of the component under consideration.<br>Note: The relation between Design pressure and Working pressure is for sure depending on the pressure level. There might be differences in the relation on a 1Mpa level and a 80Mpa pressure level. | Modification to 2.1.16 based on comment below and original definition:<br>"Design Pressure": The pressure at a settled temperature of 85°C that a component is subjected to in normal operation. The Design Pressure is equal to the Working Pressure multiplied by ~~1.175~~ 1.25." |
| 2.1.16 | Proposed Modification:<br>2.1.16 "Design Pressure": A pressure at a settled temperature of ~~65°C~~ 85°C that a component is subjected to. The Design Pressure is equal to the Working Pressure multiplied by ~~1.175~~ 1.25.<br>*The real properties of hydrogen shall be considerd in calculating the deisgn pressure at* | |

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| | *85deg.C*<br>*At side of the locations where DT uis used in the text state refer to def.* | |
| 2.1.18 | Equipment Of The Container. The text should be changed in general<br>Proposal: Container assessories | Delete the definition as it is not used in the text. |
| 2.1.19 | Excess Flow System. The main function is to close down the container system in case of pipe rupture or any other sever malfunction in the hydrogen system. The “or” in the definition could indicate that it is a limiter. There might be acceptable to have a “bleed function”: a small leak through the Excess Flow System in case it is a manual system, that need equal pressure on both side of the system for resetting/reopening after repair/service | The intention is to stop the flow not to restrict it, bleed valves are permitted by 14.4.4: “A system or single valve that shuts off the flow without manual intervention in the event of a pipe rupture or similar severe leakage.” |
| 2.1.20 | We should deal with complete containers only. Take away the Finished | “Completed” deleted and replaced with “A”. |
| 2.1.21 | Fitting Or Screwed Connection System. Change to “Connector” only. | Definition replaced with: “"Fitting" A non-permanent connector used in a piping, tubing or hose system.” |
| 2.1.25 | Do we really need this definition, if it is not more specific, for instance on how to measure (thermocouples,,,,,,,) Take away the definition | |
| 2.1.26 | The acceptance criteria for gas tight has to be dealt with in the regulation, and in more detail than in this definition. There might be a difference on what we can accept from one single component and a complete hydrogen system. The measureing time of the test is of importance, and also the pressure level. (some sealing migth have better sealing performance at high pressure than at low pressure<br>Detection method must also be worked on (bubble spray or sniffer) | 1. Delete Gas Tight Definition.<br>2. 14.1.5 Change to include pass criteria based on old Gas Tight def. + Volvo comment<br>3. 14.4.3.5 Change to include pass criteria based on old Gas Tight def<br>4. Delete 14.4.3.6 as it is now based on the new requirement for 14.1.5<br><br>See changes at the end of the document |
| 2.1.28 | Delete definition | |
| 2.1.31 | Redifinition: A system designed for transforming hydrogen into mechanical or electrical power<br>Note: Is the Hydrogen Conversion System a part of the propulsion system or not????? | Definition replaced with “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)..” |
| 2.1.34 | Proposed Modification:<br>2.1.34 "Hydrogen System" An assembly of Hydrogen Components and connecting parts fitted on motor vehicles using hydrogen, excluding the Propulsion System(s) or auxiliary power unit(s). | A revised definition of the boundary system is included. |

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| | The boundary between the Hydrogen System and the Propulsion System or auxiliary power unit is defined as the point(s) at which the Working Pressure decreases to 5Mpa or the maximum operating pressure of the Propulsion System or auxiliary power unit, whichever is higher.<br><br>Comment:<br>• During the Stuttgart-Meeting (July 5th) it was decided to shift the ”boundary” to the definitions under 2.1.34 | |
| 2.1.38 | Change to “Design Temperature”. We have to take into consideration both minimum and maximum. The word design gives us the min/max | Delete refs to min/max service temperature |
| 2.1.42 | Pressure Relief Device. Delete “upstream” and the definition will be more general. | |
| 2.1.42 | Replace existing text by ""Pressure Relief Device" A device that prevents a pre-determined pressure from being exceeded, e.g. maximum working pressure or design pressure of a component, by releasing the pressure“ | New definition: “Pressure Relief Device" A device that prevents a pre-determined pressure from being exceeded, by releasing the pressure“ |
| 2.1.43 | Delete “Prestressing” definition since the term is not used | |
| 2.1.44 | Further to the EIHP2 WG4 meeting on 5 July the proposed wording for changes to redefine the scope of the draft CGH2 regulations is as follows:<br><br>"Propulsion System" The internal combustion engine or fuel cell system used to propel the vehicle.” | |
| 2.1.44 | Proposed Modification:<br>2.1.44 "Propulsion System" The internal combustion engine or fuel cell ~~of~~ system used to propel the vehicle. | |
| 2.1.46 | We should restrict the text in the regulation to only one wording. Proposal: Use “Receptacle” all over. | New definition: “A device fitted in the vehicle used to permit refilling of the Container(s).” |
| 2.1.48 | Add “…or random faults.” | |
| 2.1.51 | Delete “standard” as that word does no give us anything | |
| 2.1.51 | The *Manufacturer(s)*,<br>The installation of the *Hydrogen Components* (obvious and fundamental differences),<br>Type(s) of *Specific Components*. | |
| 2.1.52 | Delete definition | Not required when maximum gas temperature for service and refilling is 85deg.C. |

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| 2.1.54 | This section of the regulation is definitions, and the list of components should be tranfered to the regulation text later on in the regulation. Delete the list of components and the wording after the list, as multifunctions has to be dealt with in the text later on in the regulation | Retain original first sentence only. |
| 2.1.55 | Delete definition as it is not necessary. | |
| 2.1.59 | Reword to: "Working Pressure": The gas pressure at a uniform temperature of 15°C that a component is subjected to. | |
| 2.4.1 | States a "minimum service life 20 years " while Annex 7, Paras. 6.4c & 9.6c suggest a minimum service life of 15 years. | Editorial mistake in original text, however now superceded by comments below. |
| 2.4.1 | The sentence starting with " The minimum service life……" to be removed. There might be technologies/design of containers, which could be based on complete replacement/and destruction/recycling after a given number of hours | |
| 2.4.2 | Replace everything with: Working Pressure(s) of the Hydrogen System(s) shall be specified by the vehicle manufacturer | Revised comment: "The Working Pressure(s) of the Hydrogen System shall be specified by the vehicle Manufacturer." |
| 2.4.2 | The working pressure must be greater than or equal to the pressure defined by the vehicle receptacle. | New comment 14.7.6: "The Working Pressure of the of the Receptacle shall be less than or equal to the Working Pressure of the Class O Hydrogen Components upstream of and including the first pressure regulator." |
| 2.4.3 | We should spec what the external surface shall withstand, not all it shall not withstand. Delete first part of the paragraph. Start with : The effects on external surfaces of the Hydrogen Components in…….. | |
| 2.4.6 | Take away the word "Service" | |
| 2.4.6.1 | The temperature range of materials used in Hydrogen Components shall be:<br><br>Internal combustion engine compartment: -40 to +120 deg.C<br>On board (all types of propulsion systems): -40 to +85 deg.C<br><br>For Hydrogen Components outside of the Propulsion System compartment material temperatures exceeding 65°C are considered to be sufficiently local or of short enough duration that they are not considered for the mechanical design of the equipment. | Reworded |
| 2.4.6.1 | Proposed Modification: | Reworded |

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| | 2.4.6.1 Material Temperatures<br>The temperature range of materials used in Hydrogen Components shall be:<br>~~Propulsion System~~ Internal Combustion Engine Compartment<br>-40°C to +120°C<br>~~On Board~~ Other Areas -40°C to +85°C<br><br>~~For Hydrogen Components outside of the Propulsion System compartment, material temperatures exceeding 65°C are considered to be sufficiently local or of short enough duration, that they are not considered for the mechanical design of the equipment.~~<br><br>Comment:<br>• 85°C must be possible at any time, vehicle components are always specified to minimum 85°C | |
| 2.4.6.2 | Proposed Modification:<br>2.4.6.2 Gas Temperatures<br>The Settled Temperature of gas may vary between -40°C to ~~+65°C~~ +85°C. Developed gas temperatures during filling or discharging shall not exceed +85°C.<br><br>Comment:<br>In ISO 11439 it states that the gas temperature cannot exceed 65°C, this is due to the fact that the standard is for CNG and if the temperature exceeds 65°C the pressure in the container will exceed maximum allowable filling pressure. Since this standard is exclusively for hydrogen the temperature and pressure criteria should be based on the behaviour of hydrogen. According to the rest of the document containers must be tested to maximum filling pressure and temperatures of 85°C, thus the designs will be capable of handling a settled service temperature of 85°C. | Reworded to : "The gas temperature may vary between -40°C to +85°C in normal conditions" |
| e. g. 3.1 | There are some definitions missing, e. g. Multifunctional Components | New definition added: 2.1.x "Multifunctional Component": Specific Components combined or fitted together and which may include Hydrogen Components. A Multifunctional Component is a Specific Component. |
| 3.2 | iii) difficult to understand the need for piping and instrumentation drawing for a Container. Delete the whole sub-paragraph | Also sub-para.iv) deleted as of no value |
| 4.3 | The draft does not take into consideration that a container could be assembled by | Reword: "On each *Container,* and where applicable the |

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| | multiple containers, and all of them captured inside a gas tight cover, with for instance vacum inside. A broken cover will in such cases give a destroyed container. A multiple of sub-containers in a bundle, making a complete container package, to be marked by a bundle marking | outer surface of a group of permanently encapsulated *Containers*, the *Manufacturer* shall……"<br><br>Replace "Water capacity.." with "Internal volume…" |
| 5.3 | Change from "Hydrogen Component" to "Specific Component". | |
| 5.4.2 | Change to "preceded" from "proceeded". | |
| 5.6 | Change to "an example" from "examples". | |
| 6.1.3 | The last sentence seems to be unnecessary. What does it really say? "You are now reading paragraph 6.1.3 within paragraph 6.1 – General Provisions of Chapter 6 – Specifications for Hydrogen Components. Please keep in mind that the provisions of this Chapter 6 are to be fulfilled." | |
| 6.1.5 | Proposed Modification:<br>6.1.5 Unless indicated otherwise the following Design Pressures shall be used for all Hydrogen Components other than the Container(s):<br>i) The Hydrogen System upstream of the first or only Pressure Regulator, excluding the Container shall have a Design Pressure equal to at least the Design Pressure of the Container. It shall be designed with a coefficient of safety not less than that of the Container.<br>ii) The Hydrogen System downstream of a Pressure Regulator shall be protected against overpressure and shall be designed for a burst pressure at least 3.0 times the outlet pressure (downstream Working Pressure) of the first Pressure Regulator upstream. If protected by a pressure control system the Hydrogen System downstream of a Pressure Regulator shall be protected against overpressure and shall be designed for a burst pressure of at least 3.0 times the outlet pressure (downstream Working Pressure).<br><br>Comment:<br>• In "ii) Original Draft" the Hydrogen Components will become too heavy | Reworded:<br>i) The *Hydrogen System* upstream of the first or only *Pressure Regulator* shall have a *Design Pressure* equal to at least the *Design Pressure* of the *Container*.<br><br>ii) The *Hydrogen System* downstream of a *Pressure Regulator* has a *Design Pressure* derived from the *Working Pressure* of that section of the *Hydrogen System,* unless the gas pressure never exceeds *Working Pressure* regardless of gas temperature.<br><br>New 14.1.16: "The Hydrogen System downstream of a Pressure Regulator shall be protected against overpressure due to the possible failure of the Pressure Regulator." |
| 6.1.7 | Add a new paragraph: 6.1.7 The specific components of vehicles using Hydrogen in their propulsion system shall comply with relevant electromatic compatibility (EMC) requirements according to Regulation No 10, 02 series of amendments, or equivalent | Reworded: 6.1.7 Specific Components shall be approved in accordance with the relevant electromagnetic compatibility requirements of ECE Regulation No 10, 02 series of amendments, or equivalent. |
| 6.1.8 | Change to "… in Chapter 6 and the relevant annexes…" | |

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| 6.3.1.1 | The Pressure Relief Device shall be temperature triggered only. | |
| 6.3.1.2 / 6.3.1.3 | Delete words "for/of the container". This is already given by 6.3.1. | |
| 6.3.1.2 | The trigger temperature of 110°C ± 10°C for the Pressure Relief Device seems to be very low. Even VdTÜV has a higher trigger / melting temperature. Hydrogen will see a temperature rise when it expands and compresses.<br>Some OEM's require a trigger temperature of 140°C. Bonfire tests with PRD for 140°C trigger temperature have been performed successfully.<br><br>Comment VdTÜV requires 100°C to 115°C and 125°C ± 5°C for all steel containers | Change to 120°C ± 5°C |
| 6.3.1.2 | Proposed Modification:<br>6.3.1.2 The Pressure Relief Device for the Container shall limit the pressure inside the Container by opening a temperature fusible plug at ~~110°C±10°C~~ a temperature 35°C±10°C above the maximum gas temperature of 85°C. | See above comment |
| 6.3.1.3 | Replace designed with tested, as the Annex 8A is a specification for acceptance test | "designed" replaced with "approved" |
| 6.3.2.1 | The rating of Pressure Relief Devices downstream of Pressure Regulators shall not exceed the ? Pressure the downstream components are designed for. (6.1.5 ii) | Reword to: "The Pressure Relief Device(s) downstream of Pressure Regulators shall limit the pressure to the Test Pressure of the downstream Hydrogen Components." |
| 6.3.2.2 | Proposed Modification:<br>6.3.2.2 Pressure Relief devices for protecting class 0 components shall be temperature triggered ~~except when protecting Class 1, 2 ,3 and 4 Hydrogen Components or Systems in which case they may be pressure triggered~~. | Section deleted as other types of PRD may be used for Class 0 |
| 6.3.2.2 | Class numbering not in accordance with 2.3.1 | |
| 6.3.2.3 | Replace design with test (as for 6.3.1.3) | |
| 6.5.1 | Change Working pressure with design pressure (2x) | |
| 6.6, 6.6.1 & 2 | Use receptacle only | |
| 6.10 | Use the word "Connector" only | Use "Fitting" |
| 6.10.1 | Use the word "Connector" only | Use "Fitting" |
| 6.13.1 | Proposed Modification:<br>6.13.1 Electrical components of equipment in contact with hydrogen shall:<br>i) Be insulated in such a manner that no current passes through hydrogen containing parts, | Minor change to proposed wording, see draft |

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| | ii) Have the electrical system of the device insulated from:<br>a) the body of the component,<br>b) the Container.<br>iii) The electric circuit insulation resistance, (batteries and fuel cells excluded), shall exceed 1 kΩ for each volt of the nominal voltage.<br><br>Comment:<br>• The 1 kΩ for each volt is the normal requirement (see EN 1987-3) | |
| 6.14 | Add a new paragraph 6.14: "If a test method other than those specified in Paragraph 6.1 to 6.13 above and the relevant annexes is used, its equivalence shall be proved." | Moved to 6.1.8 |
| 8.1.1 / 16.1 | Change to "…approved according to …". | |
| 8.1.2 | The authority (Technical Service or Authority?) which 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.(sufficient?) | i) Type Approval Authority<br>ii) To be compared with existing ECE regulations |
| 13.4.1 / Note 1 | Change to superscripted "[1]" instead of "(see Note 1/ below)". Change the footnote from "Note 1/:" to superscripted "[1]". | |
| 13.7 | "close to", not "closed to". | |
| 14.1.1 | Replace Working Pressure with Design Pressure | |
| 14.1.1 | "It shall reliably withstand the **electrical,** mechanical, thermal and chemical operating conditions.…" | |
| 14.1.4 | Does not give anything. Delete. | |
| 14.1.5 | Replace "The Hydrogen System shall be Gas Tight." with "The Hydrogen System shall be Gas Tight. The installed Hydrogen System shall be tested for leakage with a surface active agent without formation of bubbles or measured with a combined leakage and permeation rate less than 100 $Ncm^3$/hour or other equivalent test method." | i) Delete Gas Tight Definition.<br>ii) 14.1.5 Change to include pass criteria based on old Gas Tight def. + Volvo comment<br>iii) 14.4.3.5 Change to include pass criteria based on old Gas Tight def<br>iv) Delete 14.4.3.6 as it is now based on the new requirement for 14.1.5<br><br>See changes at the end of the document |
| 14.1.7 | First sentence: Delete "service" Delete second sentence as it does not set any regulatory demand (more a kind of basic information well known) | |

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| 14.1.8 | Delete 2nd sentence | |
| 14.1.9 | Proposed Modification:<br>14.1.9 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. | |
| 14.1.11 | Replace "….shall not damage the Hydrogen System" with "…..shall not cause leakage of the Hydrogen System." | Clause reworded |
| 14.1.12 | Dangerous. If someone start to protect (insulate) the PRD, we can start waiting for the big bang. Much better to set requirements to the material used on PRD's. Please also take into consideration that partly protection, that could accumulate for instance sand/salt, that could be kept wet over long periodes, could be worse than unprotected surfaces. | Original intention to consider location NOT protection paragraph reworded. |
| 14.1.16 | An Excess Flow System shall be part of the Hydrogen System. | |
| 14.2.1 | Proposed Modification:<br>14.2.1 A Hydrogen System shall contain at least the following components:<br><br>14.2.1.1 Container(s),<br>14.2.1.2 Automatic valve(s),<br>14.2.1.3 Excess flow system<br>14.2.1.4 Fittings or screwed connection systems,<br>14.2.1.5 Flexible fuel lines or rigid fuel lines,<br>~~14.2.1.6 Hydrogen conversion system, e.g. combustion engine, fuel cell, catalytic heater etc.,~~<br>14.2.1.6 Pressure or hydrogen remaining indicator,<br>14.2.1.7 Pressure and temperature sensors,<br>14.2.1.8 Pressure regulator(s)<br>14.2.1.9 Pressure relief device (temperature triggered),<br>14.2.1.10 Refuelling connection or receptacle,<br>14.2.1.11 Safety instrumented system,<br>14.2.1.12 Check or non-return valve(s).<br><br>Comment: | |

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| | • See 1 scope 1.1 | |
| 14.2.1.8 | Delete "and temperature" | |
| 14.3.1 | Proposed Modification:<br>14.3.1 Container(s) shall be permanently installed on-board the vehicle and may only be removed for maintenance. Container(s) shall not be installed ~~in the propulsion system compartment~~ in the Internal Combustion Engine Compartment. | |
| 14.3.2 | Container(s) can fulfil integrated functions of the vehicle. Container(s) shall be designed to fulfil the integrated function requirements plus the Container requirements.(which functions are meant here?) | Delete paragraph |
| 14.3.3 | Proposed Modification:<br>14.3.3 Container(s) including Safety Devices must be mounted and fixed so that the following accelerations can be absorbed (without damage of the safety related parts) when the Container(s) are full. No uncontrolled release of hydrogen is permitted.<br>Vehicles of categories M1 and N1:<br>a) +/-20 g in the direction of travel<br>b) +/-8 g horizontally perpendicular to the direction of travel<br><br>Vehicles of categories M2 and N2:<br>a) +/-10 g in the direction of travel<br>b) +/-5 g horizontally perpendicular to the direction of travel<br><br>Vehicles of categories M3 and N3:<br>a) +/-6.6 g in the direction of travel<br>b) +/-5 g horizontally perpendicular to the direction of travel<br><br>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.<br><br>Comment:<br>• See ECE R 110 (CNG) | |
| 14.3.5 | We have to be careful so that the secondary protection system influence on the response and performance of the main protection system. If there is a fire, the container should be drained off as soon as possible, controlled by the PRD capacity only. | Reword to clarify: "Pressure Relief Device(s) shall form the fire protection system for a Container to prevent rupture. Thermal insulation or other protective measures shall not |

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| | | influence the response and performance of the Pressure Relief Device(s)." |
| 14.3.5 | Add at start of first sentence "Temperature triggered….." | Paragraph reworded |
| 14.3.6 | Change "Container" to "Containers" | |
| 14.3.6 | 14.3.6 Container with non-metallic liners shall not be installed inside the vehicle unless integrated into a system which assures, that permeated hydrogen will be vented. Containers with non-metallic liners shall not be installed inside the vehicle unless installed inside a gas tight housing in accordance with Paragraph 14.4.3 of this Regulation.. | *Containers* with non-metallic *Liners* shall not be installed inside the vehicle unless integrated into a system which assures that permeated hydrogen will be vented outside the vehicle, e.g. it is installed inside a gas tight housing in accordance with Paragraph 14.8 of this Regulation. |
| 14.3.6 | Container with non-metallic liners shall not be installed inside the vehicle.(???This provision excludes existing solutions. Is this intended? If yes: why? If the containers are tight, their use should not be restricted) | See above |
| 14.3.7 (New) | The container design pressure must be equal to or greater than the nozzle design pressure. | See new 14.7.6 & 14.7.7: "The interface between the Hydrogen System and the refilling infrastructure shall prevent the Maximum Filling Pressure in the Class O section of the Hydrogen System being exceeded." |
| 14.4.1.3 | We don't understand the meaning behind the word Withdrawal. | Rephrase paragraph: "In the event of breakage of the refilling lines or Fuel Supply Line(s), the isolating valves referred to in Paragraphs 14.4.1.1 and 14.4.1.2. shall not be separated from the Container. |
| 14.4.1.4. | Clarification needed as point already covered in 14.4.1.3 | w para: "Automatic valves isolating each Container 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(s) and the Hydrogen Conversion System(s)." |
| 14.4.2.1 | Reword para.: „A Pressure Relief Device (temperature triggered) shall be directly installed into the Container opening in such a manner that it shall discharge the hydrogen into an atmospheric outlet line that vents to the outside of the vehicle." | Main safety philosophy of EIHP draft is to secure all routes from the Container at the Containers to avoid accidental discharges |
| 14.4.2.6 | Proposed Modification:<br>14.4.2.6 In the event of accidents~~, e.g. vehicle rolling over,~~ it must be ensured so far as is reasonably practicable that the Pressure Relief Device and the associated vent line remain capable of functioning. | |

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| | Comment:<br>• A roll over is not prescribed in the European legislation. | |
| 14.4.2.8 | Delete paragraph as it repeats the requirements of 14.1.13 | |
| 14.4.2.10 New | Introduce 1 time only use for PRD to prevent fire damage causing rupture of container before all pressure is relieved. | New para.: “Pressure Relief Devices shall not close once they have opened.” |
| 14.4.3.1 | Hard to understand that welded connections, without any NDT or eqv. can be accepted without gas tight housing, and not for instance a double ferrule connector. Both has anyway to show performance during approval test, and a double ferrule coupling might be easier to get gas tight at high strength than a welded joint. | See changes at end of comments tables |
| 14.5.9 | For all Class 0 Hydrogen Systems the complete Fuel Line assemblies shall be pressure cycle tested in accordance with Paragraph 14.3 of Annex 9 to this Regulation. Delete and replace with new 6.1.11 | |
| 14.5.10 | Requires a welding std? Delete and replace with new 6.1.11 | |
| 14.6.3 | Proposed Modification:<br>14.6.3 Any joints shall be made in locations where access is possible for inspection ~~without the use of tools~~ and also for leak testing.<br><br>Comment:<br>• Even for checking brake linings the wheels must be detached. | |
| 14.7 | Change heading to: Refuelling system. | Use “Refilling system” |
| 14.7.6 | New para | |
| 14.7.7 | New para | |
| 14.8.2 | Proposed Modification:<br>14.8.2 ~~Electric or electronic equipment~~ The electrical connections and components in the gas tight housing shall be ~~applicable for the hazardous zone 1 according to IEC 60079-10 "Electrical apparatus for explosive gas atmospheres- Part10 Classification of hazardous areas" from 12/1995 and comply with EN 50014:1997 Electrical Apparatus For Potentially Explosive Atmospheres - General Requirements, to EN 50021.~~ constructed such that no sparks are generated.<br><br>Comment: | Harmonised with R110 |

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| | • See ECE R 110 (CNG) | |
| 14.8.4 | Replace refuelling with refilling | |
| 14.10.1 | Proposed Modification:<br>14.10.1 Periodic Requalification<br>Recommendations for periodic requalification by visual inspection or testing during the service life of the Container shall be provided by the Container manufacturer on the basis of use under the service conditions specified in this Annex. Every Container shall be visually inspected at least every 36 months, and at the time of any re-installation, for external damage and deterioration, including under the support straps if used. The inspection procedure should avoid the need of disassembling the Container(s). The visual inspection shall be performed by a Technical Service approved by a Competent Authority, in accordance with the Manufacturers specifications: Containers without a marking containing mandatory information, or with labels containing mandatory information that are illegible in any way shall be removed from service. If the Container can be positively identified by manufacturer and serial number, a replacement label may be applied, allowing the Container to remain in service. | |
| Annex 7<br>General | - Within the description of the "LBB-Performance-Test" I miss the information about the number of cycles, which should be carried out. | A6ii) 15000 cycles |
| Annex 7<br>General | Temperature level for the "Hydrostatic Pressure Burst Test" and of the "Acid Environment Test" ? or is there a general definition for temperature levels for the execution of the tests, if there are no data given within the test procedure ? | Ambient |
| Annex 7, 1 | Container Types are already defined in Paragraph 2.2. | |
| Annex 7: 1 | Type 5 | Reworded: *Containers* specified in Paragraph 2.2 of this Regulation in which the type and method of construction, including *Containers* of welded construction, is not covered by Types 1 to 4, shall be type approved according to proven equivalent methods to those referred to in this Annex. |
| Ann.7, 3.2 | Delete paragraph-unnecessary. | |
| Ann.7, 5.3.2.1 i) | Carbon and manganese, contents in all cases, (Silizium, Alu are missing | Add silicon and aluminium |
| Annex 7<br>5.3.3 | Proposed Modification:<br>5.3.3. Aluminium | Also accept same argument for steel in Para 5.3.2.2 |

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| | 5.3.3.4 Tensile Properties<br>The mechanical properties of the aluminium alloy in the finished Container or Liner shall be determined in accordance with Paragraph A.1 (Appendix A of this Annex). The elongation for aluminium shall ~~be at least 12 %~~ meet the manufacturer's design specifications.<br><br>Comment:<br>• Stating that the elongation must be 12% limits possible container designs. There are some aluminium alloys that have an elongation of less than 12%, and yet they would be excellent candidates for this application | |
| Ann.7, 5.3.6 | The tensile yield strength and ultimate elongation shall be determined in accordance with Paragraph A.22 (Appendix A of this Annex). Tests shall demonstrate the ductile properties of the plastic liner material at temperatures of -50 °C or lower by meeting the values specified by the manufacturer. The polymeric material shall be compatible with the service conditions specified in Paragraph 3 of this Annex. In accordance with the method described in Paragraph A.23 (Appendix A of this Annex), the softening temperature shall be greater than130 °C or the functioning temperature of the temperature triggered pressure relief device plus 10 °C, and the melting temperature shall be the greater of 160 °C or the functioning temperature of the temperature triggered pressure relief device plus 30 °C. | Rephrase para.: "In accordance with the method described in Paragraph A.23 (Appendix A of this Annex), the softening temperature shall be greater than 130 °C and the functioning temperature of the temperature triggered pressure relief device plus 10 °C, and the melting temperature shall be greater than 160 °C and the functioning temperature of the temperature triggered pressure relief device plus 30 °C." |
| Annex 7, 5.5 iv | Design, not working (Pressure) | |
| Annex 7, 5.5.vi | Design, not Working Pressure | |
| Ann.7, 5.5 | The section should make reference to Definition 2.1.16 (in the main document) for "Design Pressure". | |
| Ann.7, 5.5 | Add new sentence: The burst pressure is equal to the Design pressure multiplied by the burst pressure ratio given in Table 7.4 of this Annex. | |
| Ann.7, 5.8 | The manufacturer shall specify programmes and procedures for | |
| Ann.7, 5.14 | The batch tests specified in this Annex for each Container type shall be conducted on Containers or Liners taken from each batch of Finished Containers or Liners. Heat treated witness samples shown to be representative of Finished Containers or Liners may also be used. Batch tests required for each Container Type are specified in Table 7.6 of this Annex. (manufacturer? Technical Service?) | Reword: The batch tests specified in this Annex for each Container type shall be conducted by the Manufacturer on Containers or Liners taken from each batch of Finished Containers or Liners. |
| Ann.7, 5.14 | In "Heat treated witness samples shown to be representative of Finished Containers or | |

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| | Liners may also be used. .” Change witness to test | |
| Annex 7<br>5.17 Change of Design – Table 7.8 | A hydrogen cycle test should not be required for type 4 tanks, if only the opening size of the boss end is changed and the liner to boss interface is not effected and the same materials are used for boss liner and seals. | Add note & reword: “A hydrogen cycle test should not be required for type 4 tanks, if only the opening size of the boss end is reduced and the liner to boss interface is not effected and the same materials are used for boss liner and seals.” |
| Ann.7, Tab.7.8 | *Delete PRD performance test* | |
| Ann.7, 6.2 ii) | “Working Pressure” shall be replaced by “Design Pressure”. | Also change design burst pressure to burst pressure for clarification |
| Ann.7, 6.4 c) | Parts i) & ii) require a minimum service life of15 years, but Section 2.4.1 in the main document states that the ”minimum service life shall be 20 years”. In addition to this, the minimum requirement for fatigue testing of 1000 refilling cycles per year of use is too low for the permitted ”Service life” defined in Section 2.4.1 (in the main document). A minimum requirement for a safety factor of 2 is necessary. It means that if up to 1000 fillings per year are allowed (in accordance with Section 2.4.1) a minimum fatigue testing requirement of 2000 cycles per year of service is necessary. Fatigue requirements normally have an higher factor of safety than 2 according to, for example, US ASTM standards for pressure vessels. Similar comments apply to Paras. 7.5.1c) & 7.6.3 and also for the fatigue requirements of Paras. 8 & 9 of Annex 7.<br><br>It is important to point out that the "Burst pressure ratio" and "Stress ratio" as stated in Table 7.4 are low even if the "Design Pressure" has been used (instead of working pressure as before). The EU-directive for pressure vessels (97/23/EC) as well as other regulations have higher requirements. | See changes to service life, fatigue cycling at end of comments and also to design pressure. |
| Ann.7, 7.2.3 | “Working Pressure” shall be replaced by “Design Pressure”. | Also change design burst pressure to burst pressure for clarification |
| Annex 7<br>7.6.5 | Comment:<br>There is a typing error in 7.6.5, please correct ~~rested~~ into tested. | |
| Annex 7<br>Table 7.8 | Comment::<br>Plastic Liner Material – Full range of testing should be included, similar to what is required for a metallic liner change, because performance of the container in these tests will be dependant on the liner material. | Also deleted type 4 from metallic containers or liners |
| Ann.7, 8.2.3 | “Working Pressure” shall be replaced by “Design Pressure”. | Also change design burst pressure to burst pressure for |

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| | | clarification |
| Ann.7, 9.3 | "Working Pressure" shall be replaced by "Design Pressure". | Also change design burst pressure to burst pressure for clarification |
| Annex 7<br>Appendix A<br>A 5 | Comment:<br>There is a typing error in A.5, please correct ISO 7866 Annex ~~D~~ into ISO 7866 Annex B | |
| Ann.7, App.A,<br>A.6 | Change 1.3 x Working Pressure to test pressure | |
| Ann.7, App.A,<br>A.7 | i) State number of containers, i.e. 2<br>ii) B) Change 1.3 x Working Pressure to Design Pressure<br>iii) D) Delete 1.3x<br>iv) D) Delete "the appropriate minimum temperature given in Paragraph 2.4.6 of this Regulation or lower" and replace by –40degC<br>v) E) Adequate recording instrumentation shall be provided to ensure the minimum temperature and pressure of the fluid within the Container is maintained during the low temperature cycling<br>vi) E) Delete: "The pressure cycling rate of b) shall not exceed 10 cycles per minute. The pressure cycling rate of d) shall not exceed 3 cycles per minute unless a pressure transducer is installed directly within the Container." | vi) Adequately described with the new text. |
| Annex 7, A.7.d | Change to "-40 °C or lower" with reference to Paragraph 2.4.6. | |
| Ann.7, App.A,<br>A.10 | i) Leak test gases to be replace with: "with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium"<br>ii) Replace working pressure with design pressure | |
| Ann.7, App.A,<br>A.11 | i) a) Change 1.5 x WP to test pressure<br>ii) Option 2, delete "at least 1.5 times Working Pressure" | |
| Ann.7, App.A,<br>A.13 | Change 1.3 x Working Pressure to the design pressure | |
| Ann.7, App.A,<br>A.14 | Change 1.3 x Working Pressure to the design pressure | |
| Annex 7<br>Appendix A<br>A 15.5 | Proposed Modification:<br>A.15.5 General Test Requirements<br>Containers shall be pressurised with nitrogen or ~~air~~ hydrogen and tested in the | Delete "or air" |

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| | horizontal position at Working Pressure.<br>Immediately following ...<br><br>Comment:<br>• There was a very serious accident in Quebec last year where three men were killed because they were testing a cylinder with air. It was recommended that testing with air be avoided. | |
| Annex 7<br>Appendix A<br>A 15.5 | At the end of the 1st sentence "……and at 25% of the Working Pressure" | |
| Annex 7, A.17 | Design, not 1.3 times the Working Pressure | |
| Annex 7, A.18 | a)The *Container* shall be pressurised to the *Design Pressure* and held at a temperature of 95 °C for not less than 1000 hours. | |
| Annex7 – Appendix A – A.18 | Change 1.3 x Working Pressure to the design pressure | |
| Annex7 – Appendix A – A.19 | Change 1.3 x Working Pressure to the design pressure | |
| Annex7 – Appendix A – A.20 | Change 1.3 x Working Pressure to the design pressure | |
| Annex7 – Appendix A – A.21 | Permeation Test: Hydrogen has a larger atomic radius than helium resulting in a larger solubility and a smaller diffusivity than helium. One effect promotes permeation, the other declines it. It is therefore hard to judge, whether a permeation test performed with helium will lead to the same results as a permeation test performed with hydrogen. Should there be a different pass /fail criteria for hydrogen and helium? | Remove reference to hydrogen, change WP to design pressure and temperature |
| Annex 7, A.21 | Use $Ncm^3$ instead of Nml. Is the value 0.25 OK for hydrogen? Compare for instance with A.10 (0.004 Ncm3/hr). | |
| Annex7 – Appendix A – A.27 | Clarified to refer to the container design. | |
| Annex7 – | This will wind up being a severe temperature cycle test. Also, I think this would be an | Change to Design Pressure |

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| Appendix A – A.27 | appropriate place to use the 1.175x value. | |
| Annex 7, C.5.iii | Use mm, not inches | |
| Ann.8A, 1. | Delete Class 3 & 4 | |
| Ann.8A, 1 | Replace WP by DP see ref | |
| Ann 8A, 2 | Set Presure = WP only!! | Changed to: “Design Pressure plus 10% of the section” |
| Ann.8A, 4. | Endurance test (applicable to pressure triggered devices only) Annex 9 (1000 operation cycles) | Change to 100 cycles as this component will operate infrequently |
| Annex 8A 5 a&b | a) Held at 85 °C while pressured for 1.5 times the number of filling cycles calculated in accordance with Paragraph 2.4.7 of this Regulation between 2.0 MPa and *Design Pressure*.<br>b) Held at - 40 °C while pressure for 1.5 times the number of filling cycles calculated in accordance with Paragraph 2.4.7 of this Regulation between 2.0 MPa and *Working Pressure*. | |
| Annex 8A, 5 | Following the immersion, the *Pressure Relief Device* shall be leak tested with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium, by applying a pressure of 1.3 times *Working Pressure* for one minute during which time the component shall be checked for external leakage. Any leakage shall not exceed 10 $Ncm^3/hr$. | |
| Ann.8B, 3. | Endurance test Annex 9<br>Manual: 20000 operation cycles<br>Automatic: 20000 operation cycles | Manual: 100 operation cycles unless located at the *Receptacle* when the number of operation cycles shall be equal to the number of test pressure cycles calculated in accordance with Paragraph 2.4.7 of this Regulation.<br>Automatic: The number of operation cycles shall be equal to four times the number of filling cycles calculated in accordance with Paragraph 2.4.7 of this Regulation. |
| Annex 8D, 3 | The number of operation cycles shall be equal to four times the number of filling cycles calculated in accordance with Paragraph 2.4.7 of this Regulation. | |
| Ann.8E, 3. | Endurance test Annex 9<br>(20000 operation cycles) | The number of operation cycles shall be equal to four times the number of filling cycles calculated in accordance with Paragraph 2.4.7 of this Regulation. |
| Annex 8G | Change to “test pressure” instead of “test-pressure”. | |

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| Annex 8G.2.3 | Delete paragraph. Already stated in Paragraph 14.5.9. | |
| Annex 8G.3.5.4.2 & 3 | TP =1.5DP<br>BP=2.25DP | |
| Annex 8G.4.5.4.2 & 3 | TP =1.5DP<br>BP=2.25DP | |
| Annex 8G.5.5.4.2 & 3 | TP =1.5DP<br>BP=2.25DP | |
| Annex 8G.3.5.1.1 | Change mixture to : "with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium" | |
| Annex 8G.3.8.1 | Change to … 0.5 m, with the … | |
| Annex 8G.4.5.1.1 | Change mixture to : "with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium" | |
| Annex 8G.5.5.1.1 | Change mixture to : "with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium" | |
| Annex 8G.5.8.1 | Change to … 0.5 m, with the … | |
| Annex 8J.1 | Change to Class 1 & 2 | |
| Annex 9,.2 | Reword to: "Table 9.1 states the applicable test procedures which have to be performed for approval of Specific Components according to their pressure classifications as defined by Paragraph 2.3 of this Regulation." | |
| Ann.9, 3.1 | Leakage tests shall be conducted with pressurised gas such as air or nitrogen containing at least 10% helium. | Gas amended to "with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium," |
| Ann.9, 3.1.1 | Change to: "*Design Pressure* shall be in accordance with Part I, Paragraph 6.1.5 of this Regulation." | |
| Annex 9,4.1 | Change to "…the durability test ~~of~~ in Paragraph 7 of this Annex shall …" | |
| Ann.9, 4.1.1 | Change to: "*Design Pressure* shall be in accordance with Part I, Paragraph 6.1.5 of this Regulation." | |
| Ann.9, 5.1, 5.3, 6.2i), 6.4-6.8 | Delete "pneumatic" | |
| Ann.9, 5.1 | The external leakage test shall include external leakage and permeation. A component shall be free from leakage through stem or body seals or other joints, and shall not show evidence of porosity in casting when tested as described below at any pneumatic pressure between zero and its Working Pressure. (this provision is not practicable, | The external leakage test shall include external leakage and permeation. A component shall be free from leakage through stem or body seals or other joints, and shall not show evidence of porosity in casting when tested as |

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| | because it offers unlimited possibilities. We would prefer 2 or 3 test steps, see example 5.2 iv) | described below.<br><br>5.2 The test shall be performed on the same component at the following conditions:<br><br>i) At the minimum service temperature (see Paragraph 2.4.6 of this Regulation) after 3 hours conditioning at this temperature and at 1, 10 and 100% of *Working Pressure*.<br>ii) At the maximum service temperature (see Paragraph 2.4.6 of this Regulation) after 3 hours conditioning at this temperature and at 1, 10 and 100% of *Design Pressure*. |
| Ann.9, 5.1.1 | Change to: "*Design Pressure* shall be in accordance with Part I, Paragraph 6.1.5 of this Regulation." | |
| Ann.9, 5.2 iv) | Test Pressure = 1%, 10% of the working pressure and working pressure | See above |
| Ann.9, 5.3 | During this test, the equipment under test shall be connected to a source of pneumatic pressure. | Pneumatic deleted. |
| Ann.9, 5.3 | Change to "…an upper pressure reading of…" | |
| Annex 9,5.4 | Reword to "Throughout the test the sample shall be tested for leakage with a surface active agent without formation of bubbles, ~~or~~ measured with a combined leakage and permeation rate less than 10 Ncm3/hour or tested by using another equivalent test method." | |
| Ann.9, 6.2 | Seat leakage tests shall be conducted with:<br>i) The inlet of the sample valve connected to a source of pneumatic pressure,<br>ii) The valve in the closed position,<br>The outlet open. | Pneumatic deleted. |
| Ann.9, 6.3 | Change to "…an upper pressure reading of…" | |
| Ann.9, 6.4 | The seat of a shut-off valve, when in the closed position, shall not leak at a rate exceeding 10 $cm^3$/hour at a pneumatic pressure at 1%, 10% of the working pressure and | Change to "….10 $Ncm^3$/hour at 1, 10 and 100% of *Design Pressure"* |

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| | working pressure . | |
| Ann.9, 6.5 | A non-return valve with a resilient seat, shall not leak at a rate exceeding 10 $cm^3$/hour when subjected to a pneumatic pressure of 50 kPa and its Working Pressure when in the closed position. | Change to "….10 $Ncm^3$/hour at 1, 10 and 100% of *Design Pressure"* |
| Ann.9, 6.8 | Pressure triggered pressure relief devices shall not leak at a rate exceeding 10 $cm^3$/hour at any pneumatic pressure at 1%, 10% of the working pressure and their Working Pressure minus 10%. | Change to:Pressure triggered *Pressure Relief Devices* shall not leak at a rate exceeding 10 $cm^3$/hour at 1, 10 and 90% of *Design Pressure* when in the closed position. |
| Annex 9,6.9 | Delete text: "At the end of the test period ~~and with the water within and exterior to the graduated cylinder at the same level,~~ the level …" | |
| Annex 9,6.9 | $V_1$ to refer to "test gas" instead of "air or nitrogen"? | |
| Annex 9,7 | Heading "Endurance Test (Continued Operation)". In Table 9.1: "Durability Tests". | |
| Annex 9,7.1 | Here, both external and internal leakage tests shall be performed after the endurance test. But in (9.7.4?,) 9.7.5 and 9.7.6 only the external test is specifically prescribed. | |
| Annex 9,7.1 / 9,7.3 | Reference to "Appendix 8" shall be "Annex 8"? | |
| Annex 9,7.3 | Change to "The component shall be securely connected to a pressurised source of dry air or nitrogen …" instead of "The component shall be connected to a pressurised source of dry air or nitrogen securely connected to a suitable fitting …". | |
| Annex 9,7.7 | Change to ".. at both the ~~appropriate~~ maximum and minimum …". | |
| Annex 9,9.1 / 9,9.2 | Change to ".. specified in Paragraphs …". | |
| Annex 9,10.1 | Change to "The test piece shall be exposed to air at ~~a temperature equal to~~ the maximum Service Temperature (see Paragraph 2.4.6 of this Regulation) for 168 hours.". | |
| Ann.9, 12 | Only applicable to containers - see Annex 7 of this Regulation. Class 0??? In contradiction to Table 9.1 in annex 9 | Delete reference to burst test for components as test can not be performed in practice as they leak first |
| Annex 9,13.1 | Change to ".. specified ~~mentioned~~ in Paragraphs …". | |
| Annex 9,13.2 | Change to ".. being ~~having been~~ submitted …". | |
| Annex 9<br>14.3 | Proposed Modification:<br>~~14.3 For all Class 0 Hydrogen Systems the complete Fuel Line assemblies shall be capable of conforming to the applicable leakage test requirements of Paragraph 5 of this Annex after being subjected to 20000 pressure cycles or a number of cycles corresponding to the specified service life. The pressure shall change from atmospheric~~ | New requirement in Pt.1 6.1.11 & 12 |

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| | ~~pressure to the Working Pressure of the Container within less than five seconds, and after a time of at least five seconds, shall decrease to atmospheric pressure within less than five seconds. The appropriate test for external leakage, as described under external leakage test in Paragraph 5 of this Annex is to be conducted immediately following this test.~~<br><br>Comment::<br>• for fuel supply lines it should be sufficient to make a leakage test and to test the connections<br>• the fuel supply line for a bus may be 15 m | |
| Annex 9<br>14.4 | Proposed Modification:<br>~~14.4 All Heat Exchangers shall be capable of conforming to the applicable leakage test requirements of Paragraph 5 of this Annex after being subjected to 20000 pressure cycles. The pressure shall change from atmospheric pressure to the Working Pressure of the Container within less than five seconds, and after a time of at least five seconds, shall decrease to atmospheric pressure within less than five seconds. The appropriate test for external leakage, as described under external leakage test in Paragraph 5 of this Annex is to be conducted immediately following this test.~~<br><br>Comment:<br>• **the working pressure of a heat exchanger is only design-specific and absolutely independent of the working pressure of the corresponding system.** | Reworded: "All hydrogen carrying parts of heat exchangers shall be capable of conforming to the applicable leakage test requirements of Paragraph 5 of this Annex after being subjected to the total number of test pressure cycles calculated in accordance with Paragraph 2.4.7 of this Regulation. The pressure shall change from atmospheric pressure to the applicable *Design Pressure* of the component within less than five seconds, and after a time of at least five seconds, shall decrease to atmospheric pressure within less than five seconds. The appropriate test for external leakage, as described under external leakage test in Paragraph 5 of this Annex is to be conducted immediately following this test." |
| Annex 9,15.1 | Change to: "…comply to the applicable leakage test requirements of Paragraph 5 and 6 of this Annex ~~with the component's leakage tests~~ after 6 hours …". | |
| Annex 9,15.2 | Delete "(0,06 in.)". | |
| Annex 9,15.2 | Delete last sentence. | |
| Annex 9,17.1 | Change to: "… shall comply to ~~be capable of conforming to~~ the applicable leakage test requirements of Paragraph 5 of this Annex, immediately after being subjected to ...". | |
| Annex 9,17.1/<br>9,17.2 | Renumber 9.17.1 to 9.17 and delete 9.17.2. | |
| Annex 10,3.1.i | Bad idea to refer to Paragraph 3 as this Paragraph (3.1) is also a part of Paragraph 3. Refer to Paragraphs 3.2 – 3.4 instead. | |

| DRAFT ECE COMPRESSED GASEOUS HYDROGEN ($CGH_2$) REGULATION Version 7<br>MODIFICATIONS | | |
|---|---|---|
| Paragraph | Proposed Modification Based On Original Comment | Remarks |
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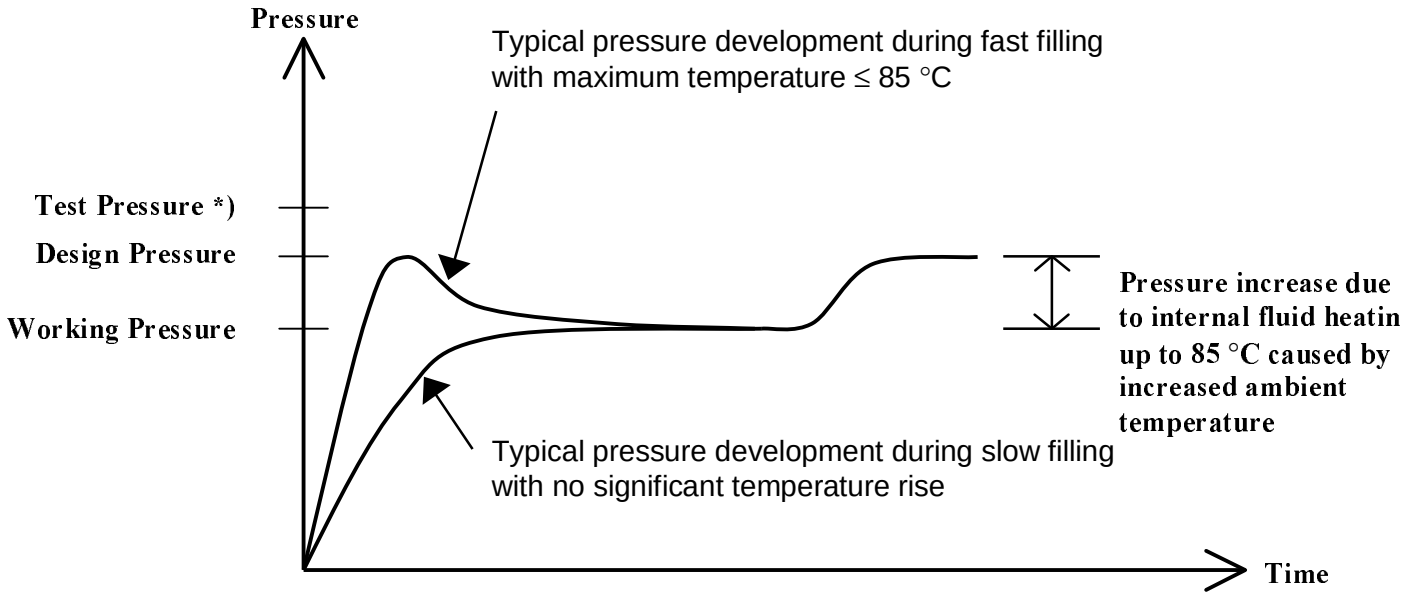


*) Test Pressure = 1.5 · Working Pressure

**2.1.x** "Usage Monitoring And Control System": A system that counts the filling cycles and prevents further use of the vehicle when a predetermined number of cycles is exceeded.

### 2.4.1 Service Life

The service life of Hydrogen Components shall be specified by the Manufacturer and may vary with different applications, however, it shall not exceed 20 years.

### 2.4.7 Filling & Test Pressure Cycles

This section is only applicable to Class O Hydrogen Components. Test pressure cycles for Class 1 and Class 2 Hydrogen Components are stated in Annexes 8 and 9 of this Regulation.

The number of filling cycles for the Hydrogen Components approved in accordance with this Regulation and its Annexes shall be at least 5000 cycles except as allowed below in this Section. The number of filling cycles is based on the design lifetime mileage of the vehicle and range with maximum fuel capacity, for example:

Design lifetime mileage of the vehicle, L = 1 000 000 km
Range with maximum fuel capacity, R = 200km
Number of filling cycles, L/R = 5000

The minimum number of test pressure cycles for the Hydrogen Components approved in accordance with this Regulation and its Annexes shall be calculated from the number of filling cycles multiplied by a safety factor of 3.

Calculation example:

Minimum number of test pressure cycles = $\gamma$L/R but where L/R is not less than 5000 cycles
= 3 x 1 000 000/200 but where L/R is not less than 5000 cycles
= 15000 pressure cycles

Alternatively the number of filling cycles for Hydrogen Components approved in accordance with this Regulation and its Annexes shall be specified by the 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, provided that a usage monitoring and control system is installed as part of the Hydrogen System. The usage monitoring and control system shall prevent any further use of the vehicle when the maximum number of filling cycles is exceeded, until the Hydrogen Components that have exceeded that value are replaced with new components. The Manufacturer shall specify the maximum number of filling cycles for the Hydrogen Components. In case this alternative method is used the number of test pressure cycles shall be calculated from the maximum number of filling cycles specified by the Manufacturer in accordance with this Paragraph multiplied by a safety factor of 3. The safety concept of the usage monitoring and control system shall be approved in accordance with Annex 10 of this Regulation.

**4.3 xi)**

The marking "Number of filling cycles xxxxx" where xxxxx is the number of filling cycles from Section 2.4.7 of this Regulation.

**Annex 1: 1 to 14 exc. 3**

Add new item “Number of filling cycles (Class O only):”

**Annex 1: 3.9**

Number of filling cycles:

**Annex 2: 1 to 17 exc 6**

Add new item “Number of filling cycles (Class O only):”

**Annex 2: 1.6.7 & 2.6.7**

Number of filling cycles:

**Annex 7: 3.1 No. Of Test Pressure Cycles**

Existing paragraph to be deleted and replaced with:
“Containers shall be approved for the number of test pressure cycles calculated in Paragraph 2.4.7 of this Regulation.”

**Annex 7: 4.2 h)**

Add “The number of filling cycles shall be specified,”

**Annex 7: 5.4 Test Pressure**

The minimum Test Pressure used shall be 1.5 x Design Pressure or ~~Working Pressure~~.

**Annex 7: 6.4 c)**

Existing section to be deleted and replaced with:

Periodic pressure cycling test. Finished Containers shall be pressure cycled in accordance with Paragraph A.13 (Appendix A to this Annex) at a test frequency defined as follows:

i) One Container from each batch shall be pressure cycled for *the total number of times calculated in accordance with Paragraph 2.4.7 if this Regulation*, with a minimum of 15,000 cycles.
ii) On 10 sequential production batches of a design family, i.e. similar materials and processes, should none of the pressure cycled Containers in i) above leak or rupture in less than *1.5 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation* (minimum 22500 cycles), then the pressure cycle test can be reduced to one Container from every 5 batches of production.
iii) On 10 sequential production batches of a design family, should none of the pressure cycled Containers in i) above leak or rupture in less *than 2.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation* (minimum 30000 cycles), then the pressure cycle test can be reduced to one Container from every 10 batches of production.
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 the required number of pressure cycles (minimum 22500 or 30000 pressure cycles respectively,) then it shall be necessary to repeat the batch pressure cycle test frequency in i) for a minimum 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 to meet the minimum cycle life requirement *calculated in accordance with Paragraph 2.4.7 of this Regulation* (minimum 15000 cycles), then the cause of failure shall be determined and corrected following the procedures in

Paragraph 5.16 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 the minimum pressure cycling requirement *calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 15000 cycles)*, then the batch shall be rejected.

**Annex 7: 6.5.3 Ambient Temperature Pressure Cycling Test**

Existing section to be deleted and replaced with:

Two Finished Containers shall be pressure cycled at ambient temperature in accordance with Paragraph A.13 (Appendix A to this Annex) to failure, or to *3.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 45000 cycles)*. The Containers shall not fail before reaching *the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 15000 cycles)*. Containers *the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 15000 cycles)* shall fail by leakage and not by rupture. Containers which do not fail within *3.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 45000 cycles)* shall be destroyed either by continuing the cycling until failure occurs, or by hydrostatically pressurising to burst. Containers exceeding *3.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 45000 cycles)* are permitted to fail by rupture. The number of cycles to failure and the location of the failure initiation shall be recorded.

**Annex 7: 7.6.3 Ambient Temperature Pressure Cycling Test**

Existing section to be deleted and replaced with:

Two Finished Containers shall be pressure cycled at ambient temperature in accordance with Paragraph A.13 (Appendix A to this Annex) to failure, or to *3.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 45000 cycles)*. The Containers shall not fail before reaching *the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 15000 cycles)*. Containers *the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 15000 cycles)* shall fail by leakage and not by rupture. Containers which do not fail within *3.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 45000 cycles)* shall be destroyed either by continuing the cycling until failure occurs, or by hydrostatically pressurising to burst. Containers exceeding *3.0 times the total number of cycles calculated in accordance with Paragraph 2.4.7 of this Regulation (minimum 45000 cycles)* are permitted to fail by rupture. The number of cycles to failure and the location of the failure initiation shall be recorded.

**Annex 7, Appendix A, A.13 AMBIENT TEMPERATURE PRESSURE CYCLING**

Pressure cycling shall be performed 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) Cycle the pressure in the Container between not more than 2.0 MPa and not less than Design Pressure or ~~1.3 times Working Pressure~~ at a rate not exceeding 10 cycles per minute.

The number of cycles to failure shall be reported, along with the location and description of the failure initiation.

**Annex 7: Appendix B, Form 1, o)**

Add “Number of filling cycles:”

**Annex 9: 14.2 to 14.7**

Replace "…after being subjected to 20000 pressure cycles." with "…after being subjected to the total number of test pressure cycles calculated in accordance with Paragraph 2.4.7 of this Regulation."

Replace "The pressure shall change from atmospheric pressure to the Working Pressure of the Container within…." with "The pressure shall change from atmospheric pressure to the applicable Design Pressure of the Component within…."

# CGH2 GAS TIGHT REFERENCES

Changes noted in the working version of cGasv7.doc:

i) Delete Gas Tight Definition.
ii) 14.1.5 Change to include pass criteria based on old Gas Tight def. + Volvo comment
iii) 14.4.3.5 Change to include pass criteria based on old Gas Tight def
iv) Delete 14.4.3.6 as it is now based on the new requirement for 14.1.5

Proposed changes to the draft based on the above comments:

~~2.1.26 "Gas Tight": A Hydrogen Component or System shall not leak when pressurised with hydrogen, helium or a gas mixture containing at least 10% hydrogen or helium, i.e. stay bubble free if using leak detection spray.~~

14.1.5 ~~A Hydrogen Component or System shall not leak when pressurised with hydrogen, helium or a gas mixture containing hydrogen or helium, i.e. stay bubble free for three minutes if using leak detection spray.~~
When pressurised with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium, the Hydrogen System shall be tested for leakage with a surface active agent without formation of bubbles for three minutes or measured with a combined leakage and permeation rate less than 100 $Ncm^3$/hour or other equivalent test method.

14.4.3.5 ~~The Gas Tight housing shall be hermetically sealed for test purposes and when tested shall be Gas Tight at an over pressure of 0.01 MPa and without any permanent deformations.~~
During testing the vent line shall be hermetically sealed and the gas tight housing shall then meet the leakage requirements of Paragraph 14.1.5 of this Regulation at an over pressure of 0.01 MPa and without any permanent deformations.

14.4.3.6 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 14.4.3.5 of this Regulation.

Additional change to the draft based on the above:

6.13.3 ~~To establish an isolated and tight electrical connection for power supply bushing, it shall be of a Gas Tight sealed type where Hydrogen Components are present or hydrogen leaks are possible.~~
Where Hydrogen Components are present or hydrogen leaks are possible, electrical connections for power supply bushing shall not permit the ingress of the test gas when pressurised with hydrogen, helium or a gas mixture containing at least 5% hydrogen or 10% helium, at an external over pressure of 0.01 Mpa.

14.1.15 In the event of Hydrogen leakage or venting, hydrogen shall not be allowed to accumulate in enclosed or semi-enclosed spaces. Hydrogen Components that can 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 14.8 of this Regulation or by an equivalent solution.

Create new 14.8 (renumber existing 14.8, 9 & 10) entitled "Gas tight housing"
Transfer old 14.4.3 to new 14.8 and delete old 14.4.3.1 (now included in 14.1.15)
Other references to gas tight housing in chapter 14.