

## Economic Commission for Europe

### Inland Transport Committee

#### Working Party on the Transport of Dangerous Goods

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#### **Proposals for amendments to Annexes A and B of ADR: construction and approval of vehicles**

### **Use of Electric and hybrid Electric vehicles for the carriage of dangerous goods : an overview for discussion**

#### **Transmitted by the Government of the Netherlands**

#### **Introduction**

1. Alternative ways of powering trucks are developed. It is to be expected that within a few years electric and hybrid electric heavy trucks will be in use on a larger scale. The use of electric vehicles is not specifically regulated in ADR. However it can be questioned what the consequences would be for the dangerous goods carried by these trucks and if additional requirements are needed for a safe use.
2. This document intends to give information about these drive systems and safety measures already in place to start discussion within the Working Party on the subject. In this document, an explanation is given why the scope is widened to include hybrid vehicles also, a description of the electric drive systems used and its hazards, fuel cell systems and other experimental systems and their possible hazards.
3. Where protection of the dangerous load is the purpose, the following general questions can be raised:
  - Are there specific issues to be taken into account concerning the electric drive system? (i.e. placing of batteries, high tension wires, inverter, electric motor, etc.)
  - Are there specific issues concerning hydrogen fuel cell systems? (i.e. strength and placing on the vehicle of containments, fuel cells, etc.)
  - What is needed for a safe functioning in an explosive atmosphere as foreseen by ADR?
4. This documents has 4 Annexes for information:
  - Annex 1: Overview of the types of electric and hybrid electric vehicles and their components;
  - Annex 2: Breakdown of the components, the hazards they present and mitigating measures;
  - Annex 3: Overview of the (technical) contents of UN Regulation No. 100;
  - Annex 4: Overview of the (technical) contents of UN Regulation No. 134.

## Extension of scope to include Fuel cell vehicles and other energy carriers

5. It appears that the weight of batteries to allow for a day driving without a recharge is unacceptable high (see Table 1). To limit the weight of the batteries a fuel cells working on hydrogen present a solution as a range extender, charging the batteries during carriage without (local) emissions of NOx and Carbon Dioxide. There are other types of range extenders as well, some are already available and some others are in an experimental phase. As this will be basically electrical driven vehicles with additional energy carriers these are included in this document as well.

**Table 1. –Estimate of weights/volumes of energy source required for a days driving of a truck**

<i>The effective energy of 3456 MJ for a days driving is based on a heavy goods vehicle on diesel fuel, 8 hours driving at 90 km/h with an average fuel consumption of 1 liter for every 3 kilometers and a thermal efficiency of 40%</i>			
<i>Type of energy carrier</i>	<i>Specific energy of fuel</i>	<i>Efficiency</i>	<i>Required volume or weight of energy carrier</i>
Diesel	36 MJ/L	40%	240 L (8 h x 90 km/h /3 = 240 L) (3456/0.4)/36 = 240)
Battery	0.875 MJ/kg <sup>a</sup>	90%	4388 kg (3456/0.9)/0.875 = 4388)
Hydrogen (Fuel cell)	11MJ/Nm <sup>3</sup>	65%	483Nm <sup>3</sup> (3456/0.65)/11 = 483) 483Nm <sup>3</sup> = 43,5 kg 483Nm <sup>3</sup> @ 350 bar = 1380 L 483Nm <sup>3</sup> @ 700 bar = 690 L

<sup>a</sup> Specific energy for batteries can deviate from this value due choice of electrodes to obtain specific properties. The value taken is at the higher scale and lower values will increase the weight of batteries needed. The given weight is without casing, inverter and control electronics.

## Description of electric drive systems

5. The electric vehicle is not new and dates back to the beginning of the automobile. The reason that vehicle with combustion engine predominate was the lack of energy density of the lead-acid batteries at that time and the recharging times. Electric vehicles have been used since for local transport, such as milk floats, golf carts, etc.

6. All electric motors work in principle on Alternating Current (AC). Direct Current (DC) motors have a system that converts mechanical energy into an alternating current (and magnetic fields) with brushes and contacts (collector). These brushes wear out quite fast so that the choice would fall on AC motors, which have less wearing parts. Recent developments in AC motors have seen a reduction in wearing parts, the reduced use of expensive and rare earth metals, an increase in power, efficiency, and smaller size.

7. At the moment of drafting this document, heavy goods vehicles are rare and concern mainly converted trucks designed for combustion engines. Another way of placing the engine is within the wheels themselves. This would give complete new design freedom for future trucks. However, at the moment of writing this paper the torque and power of the wheel motors seem to be limited to about 20 tons. It is expected that new generation wheel motors may improve the power and will be smaller in size. For the time being the lack of torque and power of wheel motors will see the use of the traditional gearbox and rear axle(s) used on

trucks with combustion engines, including the weight and mechanical losses of these components.

8. The electrical power comes from batteries. Batteries are composed of stacks of voltaic cells that contain two electrodes (anode, cathode), an electrolyte and sometimes a separator between the electrodes. Discoveries in the 1980s lead to rechargeable batteries, others than the existing lead-acid type. This led to ever more energy density with electrodes of specific material composition, such as the metal lithium. Each combination of electrodes and electrolyte brings certain properties, such as energy density, energy release rate and possible charge/discharge cycles. The pre-dominant type for vehicles at this moment is the Lithium based type with an electrolyte that is very flammable.

9. The average voltage of batteries is 400 Volts (DC). To have the best of the battery performance and service life the charge of each voltaic cell needs to be monitored and regulated. This is done by electronic systems. Because of the flammable electrolyte (kept enclosed under pressure) it is extremely important to prevent an uncontrolled de-charge (run-away), subsequent heating, venting of the flammable electrolyte and evolving fire.

10. The batteries and motor(s) are connected by high tension wires. However, to use DC voltage of the batteries requires a correction in voltage and type of current (DC to AC). This is done by an electronic inverter. For charging of the grid (Plug in / on grid electric vehicles) the same applies, the voltage has to be corrected for the battery and be inverted from AC to DC.

### **Hazards and mitigation measures**

11. Points of attention could be the location where the batteries are placed on the vehicle and the mitigating measures in case a fire may occur. Another point of attention could be the need and procedure for de-energization when FL vehicles are in areas in which explosive atmospheres can be expected.

Elaborate safety aspects for road users are contained already in UN Regulation No. 100. An overview of the content is given in Annex 3 of this document. A new Global Technical Regulation (GTR) No. 20 is developed under the 98 agreement by WP.29 following the lines of the UN Regulation No. 100. The GTR will be further developed to contain among other issues, a long-term fire test and a thermal propagation test to improve the fire resistance.

### **Fuel cell systems description**

12. A fuel cell is basically a voltaic cell with two electrodes, an electrolyte and with special membranes and separators for the entry of hydrogen gas and oxygen. The chemical reaction between hydrogen and oxygen creates a charge between the electrodes. Stacks of these cells result in a usable voltage of 125/150 volts in DC. Water is formed by the chemical reaction between hydrogen and oxygen and is released from the cells. Fuel cells work at an elevated temperature and need a cooling system to control the temperature.

13. The hydrogen is stored in containers in compressed form. Refrigerated liquefied hydrogen is also possible. At this moment the standard pressure is 350 bar for trucks and 700 bar for passenger cars. The containers are fiber reinforced plastics. Over the years the permeability for hydrogen has improved considerably.

14. A severe testing program for types of containments is described in UN Regulation No. 134. An overview is given in Annex 4 of this document. In this regulation is also regulated the location where (not) to place the containments and the strength of the fixings on the

vehicle. Important items for safety on the containments are the automatic closing shut off valve and the temperature triggered pressure relief valve.

15. The pressure has to be reduced to a workable level for the fuel cell by a pressure regulator. When parts containing hydrogen are in enclosed sections a sensor measuring the concentration of hydrogen shall be fitted. When the concentration reaches 3 vol-percent a yellow warning light will come light up on the dashboard, and when the concentration reaches 4 vol-percent a red waring light will come on and the automatic shut off valves on the containers close. A Fuel cell-vehicle is in principle an electric vehicle of which the (smaller) battery is charged during use by the Fuel-cell.

## **Hazards**

16. Although the hydrogen containers are very well tested they may present a limited hazard for damage, depending on the location of placing but the probability for catastrophic failure is very limited.

When exposed to a fire the temperature triggered pressure discharge (melting plug) opens and releases the hydrogen. Due to fact that hydrogen gas is lighter than air, the hydrogen will rise up very quickly. However the range between the upper and lower explosion limits is extensive (4.0 – 75.0 vol-%). There will be no BLEVE as with liquefied gases but the flare and heat of the flare may impinge on the load.

17. The fuel cell works on a high temperature (600 °C) but is well encapsulated not to lose the heat (inefficiency). Leaking of hydrogen in the housing for the fuel cell is prevented and controlled by the closing of the shut-off valves on the containment.

## **Experimental systems**

18. Several alternative systems for the supply of electricity are available or under study. In the Netherlands, experiments are undertaken where carbon dioxide from the air and hydrogen are used to make formic acid to limit the hazards from hydrogen storage. The formic acid is carried as fuel on the vehicle. The formic acid is run over a catalyst to produce hydrogen for a fuel cell and the carbon dioxide is emitted into the air. Other possibilities are generators driven by combustion engines of small turbines. Temporally storage of braking energy may be in flywheels with an electrical motor/generator or super capacitors.

19. Additional power may be provided by overhead power lines (like tram or train) or road sections with in ground power lines or induction.

## **Hazards**

20. The alternative systems present different hazards, as it is indicated in Annex 2 of this document.

It will comprise of a containments with formic acid and catalysts, hot combustion engines or turbines at unusual places, flywheels at high speeds and disintegration hazards, sparks from high tension electrical parts at unusual places (above or under the load area).

## **Trailers with electric (drive) equipment**

21. A new development coming on the market right now is a system of electrified axles on trailers where braking energy is recuperated and used. Some systems use a battery to store

and provide additional drive while others energize other systems such refrigeration units. Therefore high voltage equipment will be underneath the load compartment of trailers.

### **Discussion**

22. We would like to know the opinion of the members of the Working Party about the various issues raised in the above paragraphs and how to proceed with this subject.

## Annex 1

## Types of vehicles with electric drive systems and their components

Name	also known as	description	components
Parallel hybrid vehicle	HEV PHEV	The main drive is by a combustion engine with assistance of an electric motor in the driveline. Electric drive capacity is limited.	Combustion engine with fuel-, ignition- and exhaust system. Electric motor, high tension lines, battery and battery electronics. Inverter. In plug-in variety: socket and inverter.
Serial parallel hybrid vehicle	HEV PHEV	Can have either full electric drive or full drive by a combustion engine or both together. Electric drive is in driveline of combustion engine.	As parallel hybrid vehicle.
Electric vehicle	EV BEV PEV	Electric drive only vehicle with a battery	Electric motor, high tension lines, inverter, battery and battery electronics, inverter for plug-in.
Serial hybrid vehicle	HEV PHEV	Full electric drive vehicle with a battery and a generator running on a combustion engine to provide additional electricity to the battery/engine. The combustion engine is not mechanically coupled to the vehicle drive system (range extender).	As “electric vehicle” and combustion engine with fuel-, ignition- and exhaust system.
Fuel cell vehicle	FCEV FCV	Full electric drive vehicle with a battery and a fuel cell and hydrogen container(s) to provide additional electricity to the battery.	As “electric vehicle” and Fuel cell, Heating and cooling system Hydrogen storage containers, hydrogen pressure lines, pressure reducer, filling system.
<b>Experimental</b>			
Electric vehicle with other internal provisions for additional energy	-	As serial hybrid vehicle with alternative energy sources such as flywheel-generator, supercapacitors	As “electric vehicle” and Flywheel and generator, power lines, or supercapacitors and power lines.
Electric vehicle with external provisions for additional energy	-	Full electric drive vehicle with or without a battery and an external means of electricity supply to drive the vehicle or provide electricity to a battery.	As “electric vehicle” and Pantograph and power lines (overhead power lines), or undercarriage power pick-up points and power lines, or Induction Pick-up points and power lines.
Formic acid/fuel cell vehicle	-	Formic acid is made by adding Hydrogen to CO <sub>2</sub> from the air. It is used as a carrier of hydrogen without the storage issues of hydrogen.	As fuel cell vehicle with additional containers with Formic acid lines and a catalyst (with limited or no hydrogen storage).

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		The Formic acid is broken down over a catalyst to H <sub>2</sub> and CO <sub>2</sub> . The hydrogen is used by the fuel cell.	
Trailers with electric drive systems	-	It may be expected that braking energy of trailers to be recovered and stored in batteries, super capacitors or flywheel(s) for immediate use for (re)acceleration.	Motors/generators at axles, high tension lines, batteries or supercapacitors. An electrical control connection to the towing vehicle.

## Annex 2

## Components of electric vehicles, hazards and possible mitigation

Component	Description	Hazards	Mitigation	Additional remarks
Combustion engine	Producing mechanical rotational movement by combustion of liquid or gaseous fuels. The engine can be of the positive ignition type (petrol/lpg/natural gas) or the compression ignition (diesel) type. In traditional trucks engine is in front of load compartment. For serial hybrid vehicle (range extenders) other places may be found	Hot engine parts, engine 110 °C, turbo 600 °C	Shielding and use of heat resistant materials	
Fuel system	Liquid fuels: light gauge metal, or plastic low pressure tank. For petrol the line pressure is usually 4 bars, for diesel 4 bar and 950 bars for the engine fuel rail. Gaseous fuels: need evaporator (liquefied) and pressure regulator to arrive at a suitable end pressure.	Spillage of flammable liquid or gas from container or fuel lines after accident. In the form of a “mist” from high pressure lines	Fuel containers are tested for resistance to damage. Fuel pumps stop automatically in case of accidents (impact). Containers for gaseous fuels have automatic closing valves in case of accidents	
Ignition system	Only positive ignition engines have this system. It creates a high tension to produce a spark to ignite the fuel/air mixture.	Voltage up to 15.000 Volts. May create sparks	Modern vehicles have so called Coil On Plug (COP) units that enclose the high voltage parts in metal engine parts.	Beware of old style systems.
Exhaust system	Gases of the burned fuel need to be guided to a suitable place and need to be silenced. It is estimated that 40 % of the produced heat by combustion will dissipate as hot gasses. Turbo is used to re-use waste energy and charge the engine to improve performance	Exhaust gases can be up to 600 °C. Catalyst converters need to be heated up to this temperature to function. During regeneration of the soot filter a higher temperature of 800 °C is possible.	Shielding and routing of exhaust piping	Heavy goods vehicles have the catalytic converter/soot filter close to the engine, mostly just behind a front wheel, and in most cases before the load area. Catalytic converters are insulated to



				reduce heat loss.
Electric motor (drive)	High voltage (400 V) motors are used to limit the current for the required energy to be delivered. They can be DC or AC motors, although AC is preferred at this moment for costs and efficiency. Because batteries and fuel cells deliver DC an inverter is needed.	Sparks and magnetic fields. Elevated temperatures.	Modern motor design eliminates internal sparking parts.	
Battery and electronics	Batteries consist of number of voltaic cells connected together for the desired voltage. The cells used today are Lithium Ion cells with a flammable electrolyte. Charging and discharging is controlled by electronics that also protect against overloading and over-discharging.	Battery cells and electrolyte may burn when overheating. Incidents are known after malfunction of the control electronics (drying out after flooding in sea water) or mechanical damage	The control electronics (and software) prevent overheating conditions. Batteries have an additional cooling system. Safe placing on the vehicle may help against mechanical damage	
High tension buses (wiring)	Wiring connecting batteries	Electrocution persons, sparks and ignition of vapours	Differently coloured and shielded. Possibility to touch tested by UN Regl. No. 100. If electrical resistance is above value switches off as required by UN Regl. No. 100. Post-crash safety is regulated for M1 vehicles in UN Regl. Nos. 94 and 95 and M1 and N1 in UN Regl. No. 12.	
Inverters AC/DC & Voltage	Converts the DC current of the battery or fuel cell into Alternating Current. It may also transform the voltage as required.	Develop heat, may create sparks	Shielding and placing	
Fuel cell	Requires a temperature of 600 °C to function. Requires a cooling system to regulate the temperature.	The fuel cell is quite insulated to prevent loss of heat. As it processes hydrogen this may leak.	The fuel cell is usually enclosed so that heat does not pose any problem. R 134 requires leakage detectors that inform the driver and	

			eventually shuts down the hydrogen supply system.	
Hydrogen storage	Fiber reinforced plastic containers, for passenger cars in general 60 L @ 700 bar and trucks a number of containers as required for range of 350 L @ 350 bars. Containers comply with UN Regl. No. 134 and have an automatic closing valve and melting plug	Design is well tested,		
Hydrogen systems	The system contains high pressure lines and pressure regulators.	Damage may lead to leakage.	Placing of components is limited and in enclosed areas sensors are place to detect leakage of hydrogen, informing the driver and eventually shut down the system	
Supercapacitors	A capacitor consists of two electrodes an electrolyte and a membrane. They are able to store and release electrical energy for a limited period and release in fast rate. Not used for the moment in EVs but may be in the future for storing recouped braking energy.			
Pantograph - Overhead power line	A retractable connector on top of a vehicle to an overhead power line as used on rail roads. All high tension parts.	Exposed high tension parts and creation of sparks between pantograph and overhead power line.	Exposed parts and sparks are created at a high horizontal level. Questionable if this is viable and if so only for short stretches of roads.	
Road surface power lines	Experiments are undertaken in Sweden	Exposed high tension parts and creation of sparks	As "pantograph/overhead power line" but underneath the vehicle.	
Formic Acid and catalyst	Experiments are undertaken to use formic acid to store hydrogen. Carriage of the acid as a fuel is less demanding than pressurized or liquefied hydrogen. Scaling up of production of hydrogen is under development.	Additional to a fuel cell vehicle with a catalyst to produce hydrogen from the formic acid including a storage container for (liquid)	Suitable containers and lines to the catalyst. Safe placing of the fuel containers	

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		formic acid and feed lines.		
Flywheel	A flywheel may be brought up to speed as short time storage for energy. Energy to accelerate flywheel by electric motor/generator.	Risk for disintegration of flywheel and high tension in powerlines developed by a generator driven by the flywheel.	Housing may protect against disintegration. High tension lines and possible exposed parts.	System was developed earlier but attention moved to other options.

## Annex 3

### UN Regulation No. 100

#### Overview of requirements for electrical vehicles and batteries (Rechargeable Electric System)

Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train. UN Regulation No 100 applies to vehicle categories M and N.

Below and extract of the technical contents of the regulation are reproduced.

#### 5. Part I: Requirements of a vehicle with regard to its electrical safety

##### 5.1 Protection against electric shock

- Protection against direct contact – persons shall not be able to be exposed to high tension parts. It contains requirements for parts in general, connectors including of vehicle charging connectors, service disconnect (to isolate battery while servicing) and marking of high tension parts.

- Protection against indirect contact – Galvanic connection and limitations to electrical resistance to chassis, isolation resistance of parts.

##### 5.2 Gas accumulation and ventilation

5.3 Functional safety – warning of driver for vehicle being in “active drive possible mode” and de-activation of this mode while charging of the grid.

5.4 Hydrogen emissions – limitations to development of vapours from open type batteries (i.e. traditional lead-acid type batteries).

#### 6. Part II: Requirements of a Rechargeable Energy Storage System (RESS) with regard to its safety

6.2 Vibration test – battery shaken (Annex 8A).

6.3 Thermal shock test - behaviour of battery in changing temperature conditions (Annex 8B).

6.4 Mechanical impact and integrity - proven in vehicle crash test or as component (Annex 8D).

6.5 Fire resistance test - battery is exposed to an external (pool) fire (Annex 8E).

6.6 External short circuit protection – battery shall shut down when short circuited (Annex 8F).

6.7 Overcharge protection. Control device shall limit or interrupt (Annex 8G).

6.8 Over discharge protection. Control device shall limit or interrupt (Annex 8H).

6.9 Over temperature protection. Temperature shall be stabilized or charging/discharging be interrupted (Annex 8I).

6.10 Emissions (gases) (Annex 6)

## Annex 4

### UN Regulation No. 134

#### Overview of (technical) requirements for hydrogen-fueled vehicles

Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fueled vehicles (HFCV). UN Regulation No. 134 applies to vehicle categories M and N.

#### Chapter 5 Part I - Specifications of the compressed hydrogen storage system

The requirements and tests on hydrogen storage systems to be performed are in 3 sections.

##### 5.1 *Initial pressure testing and cycling of gas containment systems*

Three containments are exposed to a pressure of 225% the Normal Working Pressure (NWP) at ambient temperature. No leakage shall occur before 11.000 pressure cycles (representing a 15 year service life with 2 fillings every day) and no burst shall occur before 22.000 cycles. A baseline burst pressure is determined.

##### 5.2 *Verification test for performance durability (sequential hydraulic tests)*

Depending on the outcome of the initial pressure and cycling test 1 or 3 containments shall be additionally tested.

After an initial pressure test at 150 % of NWP, the containment shall be dropped from 1.8 meters (in some case centre of gravity) at various angles, surface damage tested, cycle pressure tested while exposed to chemicals normally found on vehicles, pressure cycle tested at -40 °C and above +85 °C. After completion of this test the residual strength shall be tested by a pressure test at 180 % of the NWP and burst test with a burst above 80% of the baseline burst pressure.

##### 5.3 *Verification on road performance*

After an initial pressure test the containment is pressure cycled with hydrogen at extreme temperatures and humidity's. The hydrogen temperature shall be -40 and +20 °C for various cycles. After each given number of cycles a permeability check shall be performed. Part of the pressure cycles shall simulate a higher outflow of hydrogen (and cooling effect) than normally encountered.

After these tests the residual pressure test at 180% of the NWP shall show no leakage and residual burst pressure shall be above 80% of the baseline burst pressure.

##### 5.4 *Verification for service termination performance in a fire*

The test shall be performed with the containment filled with hydrogen or air. When exposed to heat by a determined fire the Temperature activated pressure relief device shall prevent a burst of the containment.

##### 5.5 *The containment shall be tested with the primary closing devices*

Temperature activated pressure relief device, check-valve and shut-off valve. The valves shall be separately tested based on the requirements of part 2.

##### 5.6 *labelling requirements of individual containments*

## **Chapter 6 - Part II Specifications of specific components for the compressed hydrogen storage system**

Temperature activated pressure relief devices and check-valves and shut-off valves are to be tested to prove suitability.

Among the tests are pressure and temperature cycling tests, salt corrosion resistance, drop and vibration tests, leak test, flow capacity tests (temperature activated pressure relief devices only) and stress corrosion resistance tests.

## **Chapter 7 – Part III - Specifications of a vehicle fuel system incorporating the compressed hydrogen storage system**

This part specifies requirements for the vehicle fuel system, which includes the compressed hydrogen storage system, piping, joints, and components in which hydrogen is present.

### *7.1.1 Requirements for the fuelling system*

Prevention of reverse flow, secure connection of the fuelling nozzle, placing requirements in safe areas and labelling requirements.

### *7.1.2 Overpressure protection of the low pressure part*

Overpressure protection of the hydrogen system after the pressure regulator

### *7.1.3 Requirements for the hydrogen discharge system*

In particular where not to discharge (wheel housings, electrical equipment, passengers and luggage compartments and hydrogen containers).

### *7.1.4 Protection against flammable conditions*

Prevention of hydrogen entering passenger and luggage compartments and other enclosed areas. Where accumulation may occur the hydrogen concentration shall be sensed and the driver warned against high concentrations by a light on the dashboard. From 4% by volume the shut-off valve of the containment shall close automatically.

### *7.1.5 Fuel leakage*

The system downstream of the shut-off valve shall not leak.

### *7.1.6 Tell-tale for the driver*

The driver shall be warned by a tell-tale light on the dashboard if hydrogen concentrations exceed certain limits in enclosed areas (indication a malfunction of leakage).

## *7.2 Post-crash fuel system integrity*

Reference is made to UN Regulation Nos. 12 and 94 for frontal impact crash and UN Regulation for side impact. However UN Regulation Nos. 12, 94 and 95 are only applicable to vehicle categories M1.

When no crash test is required for a vehicle category acceleration forces are given for the various categories of vehicles. For example N3 and M3 require 6.6 G in the direction of travel (front and rear) and 5 G sideways.

### *7.2.1 Fuel leakage*

Requirements are given for leakage

### *7.2.2 Concentration limits in enclosed spaces*

Where concentrations develop above the level of 4 % the automatic shut off valve shall close within 5 seconds.

*7.2.3 Container displacements*

Container shall remain attached to the vehicle.

*7.2.4 Additional requirements*

Additional requirements for the placing of containments on the vehicle in the case no crash test is required.

In the Annex 3, 4 and 5 specific prescriptions for test given above are described in detail.

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