



**WORKING PAPER**

**DANGEROUS GOODS PANEL (DGP)  
MEETING OF THE WORKING GROUP OF THE WHOLE**

**Auckland, New Zealand, 4 to 8 May 2009**

**Agenda Item 2: Development of recommendations for amendments to the *Technical Instructions for the Safe Transport of Dangerous Goods by Air (Doc 9284)* for incorporation in the 2011/2012 Edition**

**Agenda Item 2.3: Part 3 — Dangerous Goods List, Special Provisions and Limited and Excepted Quantities**

**Agenda Item 2.4: Part 4 — Packing Instructions**

**FUEL CELL VEHICLES**

(Presented by USFCC)

**SUMMARY**

Fuel cell vehicles, fuel cell engines, and flammable gas fuel cell powered equipment have been added to UN 3166 by the UNSCETDG. Consequential amendments are necessary. This paper also proposes allowance for shipment of flammable gas powered vehicles on passenger aircraft if they meet very strict regulatory requirements. The paper also proposes raising the allowable flammable gas pressure in the vehicle fuel system on cargo aircraft while maintaining the level of safety through a limit on the percentage of the maximum working pressure. The DGP-WG is asked to consider the alternatives provided in this paper and provide guidance for submission of a subsequent paper at DGP/22.

Action by the DGP-WG is in paragraph 3.

**1. INTRODUCTION**

1.1 The entry UN 3171, **Battery-powered vehicle** or **Battery-powered equipment**, applies to vehicles and equipment powered by wet batteries, sodium batteries or lithium batteries and transported with these batteries installed. Examples of such vehicles and equipment are electrically-powered cars, lawnmowers, wheelchairs and other mobility aids. Hybrid electric vehicles powered by both an internal combustion engine and wet batteries, sodium batteries or lithium batteries, transported with the battery(ies) installed are consigned under the UN 3166 entries **Vehicle, flammable gas powered** or **Vehicle, flammable liquid powered** as appropriate.

1.2 Fuel cell powered vehicles have been developed as another alternative to internal combustion engine powered vehicles for some applications including cars, buses, fork lifts, wheelchairs, mobility devices and other self propelled equipment. A fuel cell is an electrochemical device that converts the chemical energy of a fuel and an oxidant to electrical energy (DC power), heat and reaction products

(Definition from IEC 62282-6-1). A fuel cell is essentially an electrical generator operating by a chemical reaction without combustion. The electrical power generated by the fuel cell is used in a vehicle to power the electric motors that drive the vehicle or to recharge the installed batteries.

1.3 Since the hazard involved in transporting and handling vehicles using a fuel cell are the same as the hazards involved in transporting and handling vehicles or equipment using an internal combustion engine, at its 34th Session of the UNSCETDG held in December 2008, the UN Sub-Committee agreed to revise the dangerous goods list as follows:

3166	ENGINE, INTERNAL COMBUSTION or VEHICLE, FLAMMABLE GAS POWERED or VEHICLE, FLAMMABLE LIQUID POWERED <u>or ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or ENGINE, FUEL CELL, FLAMMABLE LIQUID POWERED or VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED</u>	9			106 312	0	E0	NONE			
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1.4 ICAO considered the definition of fuel cell at its working group meeting in November, 2008 and accepted provisionally, subject to final approval at DGP/22 in November, 2009, the following definition:

“FUEL CELL. A fuel cell is an electrochemical device that converts the chemical energy of a fuel to electrical energy, heat and reaction products.”

1.5 The UN SCETDG reached a decision in December of 2008 to add the following definitions to Part 1, 1.2.1, Definitions:

- a) “Fuel Cell means an electrochemical device that converts the chemical energy of a fuel to electrical energy, heat and reaction products.”
- b) “A fuel cell engine is a device used to power equipment and consists of a fuel cell and its fuel supply, whether integrated with or separate from the fuel cell, and includes all appurtenances necessary to fulfill its function.”

## 2. DISCUSSION

2.1 An option for shipment of flammable gas engines and equipment on passenger aircraft is proposed herein, with the provision that all traces of flammable gas be purged from the system. This will assure that no traces of flammable gas remain.

2.2 Modern flammable gas vehicle systems operate at high pressures, but maintain the highest level of safety by using a design that provides for high factors of safety in the pressure receptacle.

2.3 The factor of safety to bursting for pressure receptacles is typically more than 200 per cent. Using 10 per cent of the maximum allowable working pressure keeps a high level of safety without compromising the function of the vehicle. Using 10 per cent of the allowable working pressure of the pressure receptacle raises the factor of safety to more than 2000 per cent. This level of safety will make the risk of tank bursting due to pressure essentially negligible.

3. ACTION BY THE DGP-WG

3.1 The DGP-WG is invited to:

- a) consider revising Attachment 2, GLOSSARY OF TERMS, as follows:

*(Already approved provisionally in WG-08):*

*Term and explanation*

*UN Number(s),  
When relevant*

**FUEL CELL.** A fuel cell is an electrochemical device that converts the chemical energy of a fuel to electrical energy, heat and reaction products.

*(Based on definition approved at 33<sup>rd</sup> Session of UNSCETDG):*

*Term and explanation*

*UN Number(s),  
When relevant*

**FUEL CELL ENGINE.** A device used to power equipment consisting of a fuel cell and its fuel supply, whether integrated with or separate from the fuel cell, and includes all appurtenances necessary to fulfill its function.

3166

(New definition)

*Term and explanation*

*UN Number(s),  
When relevant*

**FUEL CELL STACK.** A fuel cell or a combination of fuel cells connected together for the purpose of providing electrical power and energy to a device. A fuel cell stack may include other equipment but does not include a fuel tank.

- b) consider revising Attachment 1, List of Proper Shipping Names, Chapter 1, List of Numbers with Associated Proper Shipping Names, as follows:

3166 Engines, internal combustion, flammable gas powered  
 or Engines, internal combustion, flammable liquid powered  
 or Vehicle, flammable gas powered  
 or Vehicle, flammable liquid powered  
or Engines, fuel cell, flammable gas powered  
or Engines, fuel cell, flammable liquid powered

or Vehicle, fuel cell, flammable liquid powered  
or Vehicle, fuel cell, flammable gas powered

c) consider revising the dangerous goods list as follows:

Name	UN No.	Class or division	Subsidiary risk	Labels	State variations	Special provisions	UN packing group	Excepted quantity	Passenger aircraft		Cargo aircraft	
									Packing instruction	Max. net quantity per package	Packing instruction	Max. net quantity per package
1	2	3	4	5	6	7	8	9	10	11	12	13
Engines, internal combustion, flammable gas powered	3166	9		Miscellaneous		A67 A70 A87 A134 <u>AXXX</u>		E0	FORBIDDEN		951	No limit
Engines, internal combustion, flammable liquid powered	3166	9		Miscellaneous		A67 A70 A87 A134		E0	950	No limit	950	No limit
<u>Engines, fuel cell, flammable gas powered</u>	<u>3166</u>	<u>9</u>		<u>Miscellaneous</u>		<u>A67</u> <u>A70</u> <u>A87</u> <u>A134</u> <u>AXXX</u>		<u>E0</u>	<u>FORBIDDEN</u>		<u>951</u>	<u>No limit</u>
<u>Engines, fuel cell, flammable liquid powered</u>	<u>3166</u>	<u>9</u>		<u>Miscellaneous</u>		<u>A67</u> <u>A70</u> <u>A87</u> <u>A134</u>		<u>E0</u>	<u>950</u>	<u>No limit</u>	<u>950</u>	<u>No limit</u>
Vehicle, flammable gas powered	3166	9		Miscellaneous		A67 A70 A87 A118 A120 A134 <u>AXXX</u>		E0	FORBIDDEN		951	No limit
Vehicle, flammable liquid powered	3166	9		Miscellaneous		A67 A70 A87 A118 A120 A134		E0	950	No limit	950	No limit
<u>Vehicle, fuel cell, flammable liquid powered</u>	<u>3166</u>	<u>9</u>		<u>Miscellaneous</u>		<u>A67</u> <u>A70</u> <u>A87</u> <u>A134</u>		<u>E0</u>	<u>950</u>	<u>No limit</u>	<u>950</u>	<u>No limit</u>
<u>Vehicle, fuel cell, flammable gas powered</u>	<u>3166</u>	<u>9</u>		<u>Miscellaneous</u>		<u>A67</u> <u>A70</u> <u>A87</u> <u>A118</u> <u>A120</u> <u>A134</u> <u>AXXX</u>		<u>E0</u>	<u>FORBIDDEN</u>		<u>951</u>	<u>No limit</u>

d) consider adding a new Special Provision AXX as follows:

Axx

Vehicles or engines prepared for transportation in accordance with a quality assurance process that ensures all traces of fuel have been removed from the vehicle or engine may be transported on passenger aircraft under UN 3166 provided that all other provisions applicable to transport of the vehicle or engine

have been met. The following procedure, or another procedure approved by the competent authority of the State of Origin of the shipment, must be followed:

- a) the fuel tanks must be fully drained and flushed a minimum of three times with nitrogen or inert gas to remove any remaining flammable gas in the fuel tank (see also 5;1.6.1);
- b) the remaining nitrogen or inert gas pressure in the fuel tank after the third flushing procedure must be less than 2 bar (200 kPa);
- c) the fuel lines between the fuel tank and the internal combustion engine or the fuel cell stack must also be flushed three times with nitrogen or inert gas;
- d) for vehicles with an internal combustion engine, the valve closest to the internal combustion engine must be shut;
- e) for vehicles, machines or equipment with a fuel cell stack, the valve closest to the fuel cell stack must be closed;
- f) the engine or stack must be operated with fuel valve closed until it stalls due to lack of fuel. If the engine or the stack will not start, due to lack of fuel, it is acceptable for shipment;
- g) all valves between the fuel tank and the internal combustion engine or the fuel cell stack must be closed;
- h) the execution of this procedure must be documented by a checklist and must be confirmed by the executing individual with a signature;
- i) the described procedures are only to be executed by specifically trained persons;
- j) the shipper must confirm in writing on the dangerous goods transport document that the correct execution of the above described procedure has been carried out.

The working group is invited to consider the following alternative:

Adding the requirement that the signed checklist is to be added to the dangerous goods transport document.

e) consider either:

1) revising Special Provision A70 as follows:

A70 Internal combustion or fuel cell engines being shipped either separately or incorporated into a vehicle, machine or other apparatus, the fuel tank of which has never contained any fuel and the fuel system of which is completely empty of fuel, or that are powered by a fuel that does not meet the classification criteria for any class or division, and without batteries or other dangerous goods, are not subject to these Instructions. The words “not restricted” and the special provision number A70 must be provided on the air waybill when an air waybill is issued.

Fuel cell(s) or fuel cell stack(s) being shipped either separately or incorporated into a vehicle, machine or other device, without fuel, batteries or other dangerous goods, are not subject to these Instructions.

or

2) adding a new special provision with the text in the new paragraph above instead.

## f) consider revising Special Provision A21 as follows:

A21 This entry only applies to vehicles and equipment which are powered by wet batteries, sodium batteries or lithium batteries and which are transported with these batteries installed. Examples of such vehicles and equipment are electrically-powered cars, lawn mowers, wheelchairs and other mobility aids. Vehicles that also contain an internal combustion engine must be consigned under the entry Vehicle (flammable gas powered) or Vehicle (flammable liquid powered), as appropriate. Hybrid electric vehicles powered by both an internal combustion engine and wet batteries, sodium batteries or lithium batteries, transported with the battery(ies) installed, must be consigned under the entries UN 3166 **Vehicle, flammable gas powered** or UN 3166 **Vehicle, flammable liquid powered**, as appropriate.

Vehicles or machinery powered by a fuel cell engine must be consigned under the entries **Vehicle, fuel cell, flammable gas powered** or **Vehicle, fuel cell, flammable liquid powered**, or **Engine, fuel cell, flammable gas powered** or **Engine, fuel cell, flammable liquid powered** as appropriate. These entries include hybrid electric vehicles containing both a fuel cell and an internal combustion engine and wet batteries, sodium batteries or lithium batteries, transported with the battery(ies) installed.

## g) consider revising Special Provision A134 as follows:

A134 (312) Vehicles which contain an internal combustion engine must be consigned under the entries UN 3166 **Vehicle, flammable gas powered** or UN 3166 **Vehicle, flammable liquid powered**, as appropriate. These entries include hybrid electric vehicles powered by both an internal combustion engine and wet batteries, sodium batteries or lithium batteries, transported with the battery(ies) installed.

Vehicles or machinery powered by a fuel cell engine must be consigned under the entries **Vehicle, fuel cell, flammable gas powered** or **Vehicle, fuel cell, flammable liquid powered**, or **Engine, fuel cell, flammable gas powered** or **Engine, fuel cell, flammable liquid powered** as appropriate. These entries include hybrid electric vehicles containing both a fuel cell and an internal combustion engine and wet batteries, sodium batteries or lithium batteries, transported with the battery(ies) installed.

## h) consider revising Packing Instruction 950 (as presented in Attachment 4 to the Technical Instructions) as follows:

### Packing Instruction 950

Passenger and cargo aircraft for UN 3166 only  
(See Packing Instruction 951 for flammable gas-powered vehicles and engines or  
Packing Instruction 952 for battery-powered equipment and vehicles)

#### General requirements

Part 4, Chapter 1 requirements must be met, including:

1) **Compatibility requirements**

— Substances must be compatible with their packagings as required by 4;1.1.3.

2) **Closure requirements**

— ~~Closures must meet the requirements of 4;1.1.4.~~

<i>UN number and proper shipping name</i>	<i>Quantity — passenger</i>	<i>Quantity — cargo</i>
UN 3166 <b>Engines, internal combustion, flammable liquid powered or Vehicle, flammable liquid powered <u>or</u> <u>Vehicle, fuel cell, flammable liquid powered or</u> <u>Engine, fuel cell, flammable liquid powered</u></b>	No limit	No limit
...		
<b>Internal combustion <u>or fuel cell</u> engine shipped separately (not installed)</b>		
<ol style="list-style-type: none"><li>1) When internal combustion engines <u>or fuel cell engines</u> are being shipped separately, all fuel, coolant or hydraulic systems remaining in or on the engine must be drained as far as practicable and all disconnected fluid pipes must be sealed with leakproof caps, which are positively retained.</li><li>2) This requirement also applies to vehicles, machines or equipment containing internal combustion engines <u>or fuel cell engines</u> which are being shipped in a dismantled state such that fuel lines have been disconnected.</li></ol>		

- i) consider revising Packing Instruction 951 (as presented in Attachment 4 to the Technical Instructions) as follows:

### Packing Instruction 951

Cargo aircraft only for UN 3166 only unless Special Provision AXXX requirements are met  
(See Packing Instruction 950 for flammable liquid-powered vehicles and engines or  
Packing Instruction 952 for battery-powered equipment and vehicles)

#### General requirements

Part 4, Chapter 1 requirements must be met, including:

1) **Compatibility requirements**

- Substances must be compatible with their packagings as required by 4;1.1.3.

2) **Closure requirements**

- ~~Closures must meet the requirements of 4;1.1.4.~~

<i>UN number and proper shipping name</i>	<i>Quantity — passenger</i>	<i>Quantity — cargo</i>
UN 3166 <b>Engines, internal combustion, flammable gas powered or Vehicle, flammable gas powered or <u>Vehicle, fuel cell, flammable gas powered or Engine, fuel cell, flammable gas powered</u></b>	Forbidden	No limit

#### **ADDITIONAL PACKING REQUIREMENTS FOR COMBINATION PACKAGINGS**

##### *Flammable gas vessels*

- 1) for flammable gas-powered vehicles, machines or equipment, pressurized vessels containing the flammable gas must be completely emptied of flammable gas. Lines from vessels to gas regulators, and gas regulators themselves, must also be drained of all trace of flammable gas. To ensure that these conditions are met, gas shut-off valves must be left open and connections of lines to gas regulators must be left disconnected upon delivery of the vehicle to the operator. Shut-off valves must be closed and lines reconnected at gas regulators before loading the vehicle aboard the aircraft;

or alternatively,

- 2) flammable gas-powered vehicles, machines or equipment that have pressure receptacles (fuel tanks) equipped with electrically operated valves that close automatically in case the power is disconnected, or with manual shut-off valves, may be transported under the following conditions:
- i) the tank shut-off valves must be in the closed position and in the case of electrically operated valves, power to those valves must be disconnected;
  - ii) after closing the tank shut-off valves, the vehicle, equipment or machinery must be operated until it stops from lack of fuel before being loaded aboard the aircraft;
  - iii) in no part of the closed system must the remaining pressure of compressed gases exceed 5-10 per cent of the maximum allowable working pressure of the pressure receptacle (fuel tank) system, ~~or more than 2 000 kPa (20 bar), whichever is the lower.~~

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##### **Internal combustion or fuel cell engine shipped separately (not installed)**

- 1) When internal combustion engines or fuel cell engines are being shipped separately, all fuel, coolant or hydraulic systems remaining in or on the engine must be drained as far as practicable and all disconnected fluid pipes must be sealed with leakproof caps, which are positively retained.
- 2) This requirement also applies to vehicles, machines or equipment containing internal combustion engines or fuel cell engines which are being shipped in a dismantled state such that fuel lines have been disconnected.