



WORKING PAPER

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

Memphis, 30 April to 4 May 2007

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 2009/2010 Edition

Agenda Item 2.3: Part 3 — Dangerous Goods List and Limited Quantities Exceptions

**NEW ENTRIES FOR FUEL CELL CARTRIDGES ADOPTED BY THE
UNCOE**

(Presented by the USFCC)

SUMMARY

This paper proposes to add new entries for fuel cells cartridges in Table 3.1 of the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc. 9284) to reflect changes agreed at the UNCOE in December 2006.

Action by the DGP-WG is in paragraph 2.

1. INTRODUCTION

1.1 The UN Committee of Experts on the Transport of Dangerous Goods (UNCOE) agreed, at its third session held in Geneva on 14 December 2006, to add in the UN Model Regulations four (4) new Proper Shipping Names (PSN) to cover fuel cell cartridges containing fuels in classes or division 2.1, 4.3 and 8 and agreed to amend the Proper shipping name (PSN) of UN 3473 as indicated in 2.1 below.

2. ACTION BY THE DGP-WG

2.1 The DGP-WG is invited to add in Table 3.1, the Dangerous goods list, new proper shipping names, UN numbers, and listings, new special provisions and packing instructions for fuel cell cartridges, to reflect changes agreed at the UNCOE in December 2006 as follows:

Add the following new entries to Table 3-1:

Name 1	UN No. 2	Class or division 3	Subsidiary risk 4	Labels 5	State variations 6	Special provisions 7	UN packing group 8	Passenger aircraft		Cargo aircraft	
								Packing instruction 9	Max. net quantity per package 10	Packing instruction 11	Max. net quantity per package 12
Fuel cell cartridge or fuel cell cartridge contained in equipment or fuel cell cartridge packed with equipment, containing corrosive substances	3477	8		Corrosive		A146 A334		8XX	15 kg	8XX	50 kg
Fuel cell cartridge or fuel cell cartridge contained in equipment or fuel cell cartridge packed with equipment, containing hydrogen in metal hydride	3479	2.1		Gas flammable		A146 A339		2XX	1 kg	2XX	15 kg
Fuel cell cartridge or fuel cell cartridge contained in equipment or fuel cell cartridge packed with equipment, containing liquefied flammable gas	3478	2.1		Gas Flammable		A146 A338		2XX	1 kg	2XX	15 kg
Fuel cell cartridge or fuel cell cartridge contained in equipment or fuel cell cartridge packed with equipment, containing water-reactive substances	3476	4.3		Danger if wet		A146 A334		4XX	15 kg	4XX	50 kg

Amend UN 3473 as indicated below:

Name 1	UN No. 2	Class or division 3	Subsidiary risk 4	Labels 5	State variations 6	Special provisions 7	UN packing group 8	Passenger aircraft		Cargo aircraft	
								Packing instruction 9	Max. net quantity per package 10	Packing instruction 11	Max. net quantity per package 12
Fuel cell cartridges or fuel cell cartridge contained in equipment or fuel cell cartridge packed with equipment, containing flammable liquids	3473	3		Liquid flammable		A146		313	5 L	313	50 kg

Amend existing A146 as indicated below:

A146 This entry applies to fuel cell cartridges ~~containing flammable liquids, including methanol or methanol/water solutions.~~ including when contained in equipment or packed with equipment. Fuel cell cartridges installed in or integral to a fuel cell system are regarded as contained in equipment. Fuel cell cartridge means ~~an~~ an ~~container~~ article that stores fuel for discharge into the fuel cell-powered equipment through a valve(s) that controls the discharge of fuel into ~~such~~ equipment and is free of electric charge generating components the fuel cell. ~~The Fuel cell~~

cartridges, including when contained in equipment, must be designed and constructed to prevent the fuel from leaking during under normal conditions of transport.

~~This entry applies to fuel cell cartridge design types shown without their packaging to~~ using liquids as fuels must pass an internal pressure test at a pressure of 100 kPa (gauge) without leakage. Except for fuel cell cartridges containing hydrogen in metal hydride which shall be in compliance with A339, each fuel cell cartridge design type must be shown to pass a 1.2 meter drop test onto an unyielding surface in the orientation most likely to result in failure of the containment system with no loss of contents. Fuel cell cartridges containing hydrogen in metal hydride transported under this entry must have a water capacity less than or equal to 120 mL.

Add a new Special Provision A334 (for convenience this paper uses the same numbering system for special provisions (SP) as used by UN. It is expected, the SP number will be changed to align with the ICAO system) as follows:

A 334 A fuel cell cartridge may contain an activator provided it is fitted with two independent means of preventing unintended mixing with the fuel during transport.

Add a new special provision for fuel cell cartridges containing liquefied gas as follows:

A 338 Each fuel cell cartridge transported under this entry and designed to contain a liquefied flammable gas shall:

- a) be capable of withstanding, without leakage or bursting, a pressure of at least two times the equilibrium pressure of the contents at 55 °C;
- b) not contain more than 200 mL of liquefied flammable gas with a vapour pressure not exceeding 1 000 kPa at 55 °C; and
- c) for each unit placed in transport, pass the hot water bath test prescribed in Part 6, Chapter 5, Paragraph 5.4.2.1.

Add a new special provision for fuel cell cartridges containing hydrogen in metal hydride as follows:

A 339 Fuel cell cartridges containing hydrogen in a metal hydride transported under this entry shall have a water capacity less than or equal to 120 mL. The pressure in the fuel cell cartridge shall not exceed 5 MPa at 55 °C. The design type shall withstand, without leaking or bursting, a pressure of two (2) times the design pressure of the cartridge at 55 °C or 200 kPa more than the design pressure of the cartridge at 55 °C, whichever is greater. The pressure at which this test is conducted is referred to in the Drop Test and the Hydrogen Cycling Test as the "minimum shell burst pressure".

Fuel cell cartridges shall be filled in accordance with procedures provided by the manufacturer. The manufacturer shall provide the following information with each fuel cell cartridge:

- a) Inspection procedures to be carried out before initial filling and before refilling of the fuel cell cartridge;

- b) Safety precautions and potential hazards to be aware of;
- c) Method for determining when the rated capacity has been achieved;
- d) Minimum and maximum pressure range;
- e) Minimum and maximum temperature range; and
- f) Any other requirements to be met for initial filling and refilling including the type of equipment to be used for initial filling and refilling.

The fuel cell cartridges shall be designed and constructed to prevent fuel leakage under normal conditions of transport. Each cartridge design type, including cartridges integral to a fuel cell, shall be subjected to and shall pass the following tests:

Drop test

A 1.8 metre drop test onto an unyielding surface in four different orientations:

- a) Vertically, on the end containing the shut-off valve assembly;
- b) Vertically, on the end opposite to the shut-off valve assembly;
- c) Horizontally, onto a 38 mm steel apex, with the steel apex in the upward position; and
- d) At a 45° angle on the end containing the shut-off valve assembly.

There shall be no leakage, determined by using a soap bubble solution or other equivalent means on all possible leak locations, when the cartridge is charged to its rated charging pressure. The fuel cell cartridge shall then be hydrostatically pressurized to destruction. The recorded burst pressure shall exceed 85% of the minimum shell burst pressure.

Fire test

A fuel cell cartridge filled to rated capacity with hydrogen shall be subjected to a fire engulfment test. The cartridge design, which may include a vent feature integral to it, is deemed to have passed the fire test if:

- a) The internal pressure vents to zero gauge pressure without rupture of the cartridge; or
- b) The cartridge withstands the fire for a minimum of 20 minutes without rupture.

Hydrogen cycling test

This test is intended to ensure that a fuel cell cartridge design stress limits are not exceeded during use. The fuel cell cartridge shall be cycled from not more than 5% rated hydrogen capacity to not less than 95% rated hydrogen capacity and back to not more than 5% rated hydrogen capacity. The rated charging pressure shall be used for charging and temperatures shall be held within the operating temperature range. The cycling shall be continued for at least 100 cycles. Following the cycling test, the fuel cell cartridge shall be charged and the water volume displaced by the cartridge shall be measured. The cartridge design is deemed to have passed the hydrogen cycling test if the water volume displaced by the cycled cartridge does not

exceed the water volume displaced by an uncycled cartridge charged to 95% rated capacity and pressurized to 75% of its minimum shell burst pressure.

Production leak test

Each fuel cell cartridge shall be tested for leaks at 15 °C ± 5 °C, while pressurized to its rated charging pressure. There shall be no leakage, determined by using a soap bubble solution or other equivalent means on all possible leak locations.

Each fuel cell cartridge shall be permanently marked with the following information:

- a) The rated charging pressure in megapascals (MPa);
- b) The manufacturer's serial number of the fuel cell cartridges or unique identification number; and
- c) The date of expiry based on the maximum service life (year in four digits; month in two digits).

To align with UN POO4, amend packing instruction 313 as indicated below:

313	PACKING INSTRUCTION 313	313
<p>This instruction applies to UN 3473 on passenger and cargo aircraft.</p>		
<p><u>The requirements of Part 4, 1.1.1 to 1.1.3, and 1.1.7 must be met. The following packagings are authorized:</u></p>		
<p><u>1) For fuel cell cartridges, containing flammable liquid must be packed in accordance with the general packing requirements of 4.1 and be in wooden (4C1, 4C2), plywood (4D), fibreboard (4G) or reconstituted wood (4F) boxes, plywood drums (1D), fibre drums (1G), plastic drums (1H2), plastic jerricans (3H2) or solid plastic boxes (4H2) of Packing Group II. The fuel cells must be incapable of short-circuiting and be securely cushioned in the packagings; and</u></p>		
<p>If fuel cell cartridges are shipped as an integral component of assembled equipment, they must be securely installed and protected against contact with other articles so as to prevent short circuits.</p>		
<p><u>2) For fuel cell cartridges contained in equipment or packed with equipment, strong outer packagings. Large robust equipment containing fuel cell cartridges may be transported unpackaged. When fuel cell cartridges are packed with equipment, they must be packed in inner packagings or placed in the outer packaging with cushioning material or divider(s) so that the fuel cell cartridges are protected against damage that may be caused by the movement or placement of the equipment and the cartridges contents within the outer packaging. Fuel cell cartridges which are installed in equipment must be protected against short circuit and the entire system must be protected against inadvertent operation.</u></p>		

Add three (3) new PIs as indicated below:

2XX	PACKING INSTRUCTION 2XX	2XX
<p><u>This instruction applies to UN 3478 and UN 3479 on passenger and cargo aircraft.</u></p> <p><u>The requirements of Part 4, 1.1.1 to 1.1.3, and 1.1.7 must be met. The following packagings are authorized:</u></p> <p><u>The following packagings are authorized:</u></p> <ol style="list-style-type: none"> <u>1) For fuel cell cartridges, wooden (4C1, 4C2), plywood (4D), fibreboard (4G), or reconstituted wood (4F) boxes, plywood drums (1D), fibre drums (1G), plastic drums (1H2), plastic jerricans (3H2) or solid plastic boxes of Packing Group II; and</u> <u>2) For fuel cell cartridges contained in equipment or packed with equipment, strong outer packagings. Large robust equipment containing fuel cell cartridges may be transported unpackaged. When fuel cell cartridges are packed with equipment, they shall be packed in inner packagings or placed in the outer packaging with cushioning material or divider(s) so that the fuel cell cartridges are protected against damage that may be caused by the movement or placement of the contents within the outer packaging. Fuel cell cartridges which are installed in equipment shall be protected against short circuit and the entire system shall be protected against inadvertent operation.</u> 		

4XX	PACKING INSTRUCTION 4XX	4XX
<p><u>This instruction applies to UN 3476 on passenger and cargo aircraft.</u></p> <p><u>The requirements of Part 4, 1.1.1 to 1.1.3, and 1.1.7 must be met. The following packagings are authorized:</u></p> <p><u>The following packagings are authorized:</u></p> <ol style="list-style-type: none"> <u>1) For fuel cell cartridges, wooden (4C1, 4C2), plywood (4D), fibreboard (4G), or reconstituted wood (4F) boxes, plywood drums (1D), fibre drums (1G), plastic drums (1H2), plastic jerricans (3H2) or solid plastic boxes of Packing Group II; and</u> <u>2) For fuel cell cartridges contained in equipment or packed with equipment, strong outer packagings. Large robust equipment containing fuel cell cartridges may be transported unpackaged. When fuel cell cartridges are packed with equipment, they shall be packed in inner packagings or placed in the outer packaging with cushioning material or divider(s) so that the fuel cell cartridges are protected against damage that may be caused by the movement or placement of the contents within the outer packaging. Fuel cell cartridges which are installed in equipment shall be protected against short circuit and the entire system shall be protected against inadvertent operation.</u> 		

8XX

PACKING INSTRUCTION 8XX

8XX

This instruction applies to UN 3477 on passenger and cargo aircraft.

The requirements of Part 4, 1.1.1 to 1.1.3, and 1.1.7 must be met. The following packagings are authorized:

The following packagings are authorized:

- 1) For fuel cell cartridges, wooden (4C1, 4C2), plywood (4D), fibreboard (4G), or reconstituted wood (4F) boxes, plywood drums (1D), fibre drums (1G), plastic drums (1H2), plastic jerricans (3H2) or solid plastic boxes of Packing Group II; and
- 2) For fuel cell cartridges contained in equipment or packed with equipment, strong outer packagings. Large robust equipment containing fuel cell cartridges may be transported unpackaged. When fuel cell cartridges are packed with equipment, they shall be packed in inner packagings or placed in the outer packaging with cushioning material or divider(s) so that the fuel cell cartridges are protected against damage that may be caused by the movement or placement of the contents within the outer packaging. Fuel cell cartridges which are installed in equipment shall be protected against short circuit and the entire system shall be protected against inadvertent operation.

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