

## Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

Sub-Committee of Experts on the Transport of Dangerous Goods

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Electric storage systems

### Fuel cells containing dangerous goods

#### Revision of document ST/SG/AC.10/C.3/2010/5

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#### Introduction

1. The five entries for fuel cell cartridges (UN 3473, 3476, 3477, 3478 and 3479), which appear in the UN Model Regulations, refer to **Fuel cell cartridges** or **Fuel cell cartridges contained in equipment** or **Fuel cell cartridges packed with equipment**. The following dangerous goods are currently permitted in fuel cell cartridges: “**Flammable liquids**” UN 3473, “**Water reactive substances**” UN 3476, “**Corrosive substances**” UN 3477, “**Liquefied flammable gas**” UN 3478, and “**Hydrogen in metal hydride**” UN 3479. No reference is made in the Model Regulations on how to classify and transport fuel cells containing dangerous goods permitted in fuel cell cartridges. Such fuel cells are currently commercially available and a demonstration of some of these products is proposed. A fuel cell differs from a fuel cell cartridge in its capacity of generating an electrical current once activated. A fuel cell usually consist of a few internal parts which might include an integral reservoir for the fuel, stacks, tubes, pipes, control system, etc. Provided proper precaution is taken to prevent unintended activation during transport, the hazard inherent to a fuel cell containing a specific fuel is equivalent to the hazard inherent to a cartridge containing the same fuel. This assumes that both the fuel cell and the cartridges meet the same minimum design and construction criteria’s.

2. SP 328 applies to the five fuel cell cartridges entries which appear in the Model Regulations. The third sentence of SP 328 explains that a fuel cell cartridge is an article that store fuel for discharge into a fuel cell through a valve(s) that control the discharge of fuel into the fuel cell. It could be argued that since a fuel cell meets the definition of a fuel cell cartridge it is considered fuel cell cartridges and therefore should be transported as such. This interpretation is open to debate and not universally accepted. A fuel cell is a more sophisticated article than a cartridge and it purpose is to generate electricity when activated. Furthermore, a fuel cell often contains a battery used for the controls and/or activation of the fuel cell. This hazard will need to be taken into account during transport.

3. This paper propose to expand the current provisions for fuel cell cartridges to permit the safe transport of **fuel cells** or/and **fuel cell cartridges**, containing one of the permitted dangerous goods. To achieve the above objective, the following amendments are proposed:

- Expand the proper shipping name of UN 3473, 3476, 3477, 3478 and 3479, appearing in Chapter 3.2, “Dangerous Goods List”, Column 2, under “Name and description”, as indicated in Proposal A thereafter;
- Amend SP 328 and SP 339, appearing in Chapter 3.3, paragraph 3.3.1, as indicated in Proposal B;
- Amend packing instruction P004 as indicated in Proposal C;
- Amend the “Alphabetical list of the substances and articles” as indicated in proposal D.

## Proposal A

4. Expand the proper shipping name of UN 3473, 3476, 3477, 3478 and 3479, appearing in Chapter 3.2, “Dangerous Goods List”, Column 2, under “Name and description”, as indicated in the following section:

UN No.	Name and description	Cl. or Div	Sp, Prov.	Ltd. Qty.	Ltd. Qty.	Packing Inst.
1	2	3	6	7a	7b	8
-	3.1.2	2.0	3.3	3.4	3.5	4.1.4
3473	<u>FUEL CELLS</u> or FUEL CELL CARTRIDGES or <u>FUEL CELLS CONTAINED IN EQUIPMENT</u> or FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT or <u>FUEL CELLS PACKED WITH EQUIPMENT</u> or FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT, containing flammable liquids	3	328	1L	E0	P004
3476	<u>FUEL CELLS</u> or FUEL CELL CARTRIDGES or <u>FUEL CELLS CONTAINED IN EQUIPMENT</u> or FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT or <u>FUEL CELLS PACKED WITH EQUIPMENT</u> or FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT, containing water-reactive substances	4.3	328 334	500 ml or 500 g	E0	P004
3477	<u>FUEL CELLS</u> or FUEL CELL CARTRIDGES or <u>FUEL CELLS CONTAINED IN EQUIPMENT</u> or FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT or <u>FUEL CELLS PACKED WITH EQUIPMENT</u> or FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT, containing corrosive substances	8	328 338	120 ml	E0	P004

3478	<u>FUEL CELLS or FUEL CELL</u> CARTRIDGES or <u>FUEL CELLS CONTAINED IN</u> <u>EQUIPMENT or FUEL CELL</u> CARTRIDGES CONTAINED IN EQUIPMENT or <u>FUEL CELLS PACKED WITH</u> <u>EQUIPMENT or FUEL CELL</u> CARTRIDGES PACKED WITH EQUIPMENT, containing liquefied flammable gas	2.1	328	120 ml	E0	P004
3479	<u>FUEL CELLS or FUEL CELL</u> CARTRIDGES or <u>FUEL CELLS CONTAINED IN</u> <u>EQUIPMENT or FUEL CELL</u> CARTRIDGES CONTAINED IN EQUIPMENT or <u>FUEL CELLS PACKED WITH</u> <u>EQUIPMENT or FUEL CELL</u> CARTRIDGES PACKED WITH EQUIPMENT, containing hydrogen in metal hydride	2.1	328 339	120 ml	E0	P004

## Proposal B

Amend SP 328 and SP 339, appearing in Chapter 3.3, paragraph 3.3.1, as indicated below:

328 This entry applies to fuel cells and fuel cell cartridges 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 article that stores fuel for discharge into the fuel cell through a valve(s) that controls the discharge of fuel into the fuel cell. Fuel cells and fuel cell cartridges, including when contained in equipment, shall be designed and constructed to prevent fuel leakage under normal conditions of transport.

Fuel cell and fuel cell cartridge design types using liquids as fuels shall pass an internal pressure test at a pressure of 100 kPa (gauge) without leakage.

Except for fuel cells and fuel cell cartridges containing hydrogen in metal hydride which shall be in compliance with special provision 339, each fuel cell and fuel cell cartridge design type shall 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.

Lithium ion or lithium metal cells and/or batteries meeting the requirements of SP 188 may be installed in the fuel cell.

339 In this special provision, replace all reference to “fuel cell cartridges”, “cartridges”, “cartridge” respectively with “fuel cells and/or fuel cell cartridges”, “fuel cells and/or fuel cell cartridges”, “fuel cell and/or cartridge”, as follows (highlighted):

Fuel cells and/or 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 and/or fuel cell cartridge shall not exceed 5 MPa at 55 °C. The design type shall withstand, without leaking or bursting, a pressure of two times the design pressure of the fuel cell and/or fuel cell cartridge at 55 °C or 200 kPa more than the design pressure of the fuel cell and/or fuel cell 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 cells and/or 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 and/or fuel cell cartridge:

- (a) Inspection procedures to be carried out before initial filling and before refilling of the fuel cell and/or 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 cells and/or fuel cell cartridges shall be designed and constructed to prevent fuel leakage under normal conditions of transport. Each fuel cell and/or 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 steel apex with a diameter of 38 mm, 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 fuel cell and/or cartridge is charged to its rated charging pressure. The fuel cell and/or 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 and/or fuel cell cartridge filled to rated capacity with hydrogen shall be subjected to a fire engulfment test. The fuel cell and/or 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 fuel cell and/or cartridge; or
- (b) The fuel cell and/or cartridge withstands the fire for a minimum of 20 minutes without rupture.

## Hydrogen cycling test

This test is intended to ensure that fuel cell and/or fuel cell cartridge design stress limits are not exceeded during use.

The fuel cell and/or fuel cell cartridges 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 and /or fuel cell cartridge shall be charged and the water volume displaced by the fuel cell and /or fuel cell cartridge shall be measured. The fuel cell and /or fuel cell cartridge design is deemed to have passed the hydrogen cycling test if the water volume displaced by the cycled fuel cell and /or fuel cell cartridge does not exceed the water volume displaced by an uncycled fuel cell and /or fuel cell cartridge charged to 95% rated capacity and pressurized to 75% of its minimum shell burst pressure.

## Production leak test

Each fuel cell and/or fuel cell cartridge shall be tested for leaks at  $15\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ , 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 and/or 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).

## Proposal C

Amend packing instruction P004 as indicated below:

P004	PACKING INSTRUCTION	P004
This instruction applies to UN Nos. 3473, 3476, 3477, 3478 and 3479.		
The following packagings are authorized provided that the general provisions of 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.1.6 and 4.1.3 are met:		
<ol style="list-style-type: none"> <li>(1) For fuel cells and fuel cell cartridges, packagings conforming to the packing group II performance level; and</li> <li>(2) For fuel cells and/or fuel cell cartridges contained in equipment or packed with equipment, strong outer packagings. Large robust equipment (see 4.1.3.8) containing fuel cell or fuel cell cartridges may be transported unpackaged. When fuel cells or 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 or fuel cell cartridges are protected against damage that may be caused by the movement or placement of the contents within the outer packaging. Fuel cells and fuel cell cartridges which are installed in equipment shall be protected against short circuit and the entire system shall be protected against inadvertent operation.</li> </ol>		

## Proposal D

Amend the alphabetical list of the substances and articles as indicated below:

<a href="#">FUEL CELLS containing corrosive substances</a>	<a href="#">8</a>	<a href="#">3477</a>
FUEL CELL CARTRIDGES containing corrosive substances	8	3477
<a href="#">FUEL CELLS CONTAINED IN EQUIPMENT containing corrosive substances</a>	<a href="#">8</a>	<a href="#">3477</a>
FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT containing corrosive substances	8	3477
<a href="#">FUEL CELLS PACKED WITH EQUIPMENT containing corrosive substances</a>	<a href="#">8</a>	<a href="#">3477</a>
FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT containing corrosive substances	8	3477
<a href="#">FUEL CELLS containing flammable liquids</a>	<a href="#">3</a>	<a href="#">3473</a>
<a href="#">FUEL CELLS CONTAINED IN EQUIPMENT containing flammable liquids</a>	<a href="#">3</a>	<a href="#">3473</a>
FUEL CELL CARTRIDGES containing flammable liquids	3	3473
<a href="#">FUEL CELLS PACKED WITH EQUIPMENT containing flammable liquids</a>	<a href="#">3</a>	<a href="#">3473</a>
FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT containing flammable liquids	3	3473
FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT containing flammable liquids	3	3473
<a href="#">FUEL CELLS containing hydrogen in metal hydride</a>	<a href="#">2.1</a>	<a href="#">3479</a>

FUEL CELL CARTRIDGES containing hydrogen in metal hydride	2.1	3479
<a href="#">FUEL CELLS CONTAINED IN EQUIPMENT containing hydrogen in metal hydride</a>	<a href="#">2.1</a>	<a href="#">3479</a>
FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT containing hydrogen in metal hydride	2.1	3479
<a href="#">FUEL CELLS PACKED WITH EQUIPMENT containing hydrogen in metal hydride</a>	<a href="#">2.1</a>	<a href="#">3479</a>
FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT containing hydrogen in metal hydride	2.1	3479
<a href="#">FUEL CELLS CONTAINED IN EQUIPMENT containing liquefied flammable gas</a>	<a href="#">2.1</a>	<a href="#">3478</a>
<a href="#">FUEL CELLS PACKED WITH EQUIPMENT containing liquefied flammable gas</a>	<a href="#">2.1</a>	<a href="#">3478</a>
<a href="#">FUEL CELLS containing liquefied flammable gas</a>	<a href="#">2.1</a>	<a href="#">3478</a>
FUEL CELL CARTRIDGES containing liquefied flammable gas	2.1	3478
FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT containing liquefied flammable gas	2.1	3478
FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT containing liquefied flammable gas	2.1	3478
FUEL CELL CARTRIDGES containing water-reactive substances	4.3	3476
FUEL CELL CARTRIDGES CONTAINED IN EQUIPMENT containing water-reactive substances	4.3	3476
<a href="#">FUEL CELLS containing water-reactive substances</a>	<a href="#">4.3</a>	<a href="#">3476</a>

<a href="#"><u>FUEL CELLS CONTAINED IN EQUIPMENT containing water-reactive substances</u></a>	<a href="#"><u>4.3</u></a>	<a href="#"><u>3476</u></a>
<a href="#"><u>FUEL CELLS PACKED WITH EQUIPMENT containing water-reactive substances</u></a>	<a href="#"><u>4.3</u></a>	<a href="#"><u>3476</u></a>
FUEL CELL CARTRIDGES PACKED WITH EQUIPMENT containing water- reactive substances	4.3	3476