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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

Twenty-seventh session, 4-8 July 2005
Item 6 of the provisional agenda

LISTING, CLASSIFICATION AND PACKING

New entries for fuel cell system containing flammable gas

Submitted by the expert from Japan

Background

1. At the 25th session of the Sub-Committee, the expert from Japan proposed to classify fuel cell cartridges containing flammable gas in Class 9 (ST/SG/AC.10/C.3/2004/77). The proposal was discussed at the 26th session and the Sub-Committee did not adopt the proposal to assign fuel cell cartridges containing flammable gas to Class 9. The expert from Japan was invited to prepare revised proposals for consideration at the forthcoming session.

Introduction

2. In the proposal definitions of "**Fuel cell system"** means fuel cell cartridge that is the refillable receptacle containing metal hydride and hydrogen, with or without fuel cell power unit as an electric generating device.

3. The fuel cell cartridge is not merely a fuel receptacle but safe article designed and manufactured for fuel cells. The cartridge is equipped with a valve used to supply hydrogen to fuel cells power unit and allow hydrogen to flow out only at the time when it is connected to the fuel cell power unit.
The cartridge and the fuel cell power unit is ensured against any damages during transport by proposed various performance tests, it does not rupture under normal conditions of transport.

4. Entry for the hydrogen in metal hydrides is provided in the Dangerous Goods List of Chapter 3.2 as “HYDROGEN IN A METAL HYDRIDE STORAGE SYSTEM”(UN3468). The entry does not limit capacity and pressure of hydrogen, but the fuel cell cartridge have limited capacity and low pressure of hydrogen used as a small size of receptacle.

5. Metal hydride contained in the fuel cell cartridge does not have properties of spontaneous combustion and self-heating when tested in accordance to the Test N.2 and N.4 respectively in the UN Manual of Test and Criteria, Part III.

6. The amount of hydrogen contained in the fuel cell cartridge is limited to not exceeding 150Nl*. In addition, hydrogen gas pressure in the fuel cell cartridge is limited to 5.0 MPa at ambient temperature of 55℃. The water capacity of fuel cell cartridge is limited to not exceeding 350ml.

*Nl (normal litre) means volume of gas in litre at 0°C and 1 atmospheric pressure.

7. In the fuel cell cartridge, 93% of hydrogen is absorbed in metal hydride and only 7% of hydrogen remains as gaseous state. And even from the fuel cell cartridge with the maximum capacity of 150Nl of hydrogen, only 1g(11Nl) of hydrogen gas will be released instantaneously when valve is intentionally or by accident opened in the air. Since metal hydride is cooled down as it releases hydrogen due to an endothermic decomposition reaction of the hydride compound, the remaining hydrogen that is absorbed in metal hydride will be released very slowly.

8. The structure of fuel cell cartridge is strong enough, so no leakage was found by our test even at 10.0 MPa, which is 2 times of the pressure stated the above Para.6.

9. The expert from Japan proposes that fuel cell system be assigned to Class 2.1 and they can be shown to meet the requirements of a series of six tests that are intended to minimize the probability of leakage of hydrogen or metal hydride under normal conditions of transport.

10. The test methods proposed by us that include an altitude simulation test, an extreme temperature exposure test, a vibration test, a drop test, a crush test and an expansion test, are intended to ensure that the fuel cell system are robust, resistant to leakage and afford a high level of safety in transport. Tests 1, 2, 3 and 4 simulate environments during transportation. Test 5 ensures strength of fuel cell cartridge against compression. And Test 6 ensures strength of fuel cell cartridge against inner pressure caused expansion of metal hydride during absorbing hydrogen.

Proposals

11. Add a new entry to the Dangerous Goods List as follows:

UN No.	Name and description	Class	Sub-risk	PG	SP	LQ	Packagings and IBCs		Portable tanks	
							Packing instruction	Special provisions	Portable tank instruction	Portable tank special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
3xxx	FUEL CELL SYSTEM containing hydrogen and metal hydride	2.1			xxx xxy	See SPxxy	P003	PPxx		

12. Add a new Special Provision as follows:

"SP xxx : This entry applies to FUEL CELL SYSTEM containing hydrogen and metal hydride subject to meet the following requirements:

(a) The amount of hydrogen is not exceeding 150Nl;

(b) The internal pressure of the cartridge is not exceeding 5.0 MPa at 55℃;

(c) The water capacity of the cartridge is not exceeding 350ml;

(d) No leakage shall be found even at 10.0 MPa at 55℃;

(e) The metal hydride does not have properties of self heating and spontaneous combustion;

(f) The valve equipped with cartridge shall be provided with protection against inadvertent discharge;

(g) Each fuel cell system is of the type proven to meet the requirements of the tests specified in Section 3X of the Manual of Tests and Criteria, Part III;

(h) The testing requirements in Section 3X of the Manual of Tests and Criteria do not apply to production runs or pre-production prototypes consisting of not more than 100 fuel cell systems, when these devices are transported for testing, if:

(i) Fuel cell systems are transported in an outer packaging meeting the packing group I performance level; and

(ii) Hydrogen gas contained in fuel cell cartridge shall not exceed 10% of its designed capacity."

"SP xxy : For fuel cell system containing hydrogen and metal hydride the limited quantity value is 350ml."

13. In P003 add a new PPxx as follows:-

"PPxx For UN 3xxx, packaging shall not exceed 55 kg net mass for fibreboard or 125kg net mass for other packaging. When fuel cell systems are packed with equipment, they shall be packed in inner packagings or placed in the outer packaging with cushioning material so that the systems are protected against damage that may be caused by the movement or placement of the equipment and the cartridges within the outer packaging. When fuel cell cartridges installed in fuel cell systems are transported, they shall be protected against short circuit and the fuel cell system must be protected from inadvertent operation."

14. Add new tests in the Manual of Tests and Criteria, Part III, Section 3X. for fuel cell system as follows:-.

"SECTION 3X CLASSIFICATION PROCEDURES, TEST METHODS AND CRITERIA RELATING TO FUEL CELL SYSTEM OF CLASS 2

3X.1 Purpose

This section presents the procedures to be followed for the classification of fuel cell system (see UN 3xxx and applicable special provisions of Chapter 3.3 of the Model Regulations.).

3X.2 Scope

3X.2.1 Fuel cell system shall be subjected to the tests, as required by special provision xxx of Chapter 3.3 of the Model Regulations prior to the transport of a particular type of these articles. Fuel cell system that differs from a tested design type by a change that would materially affect the test results shall be considered to be new design types and shall be subjected to the required tests.

3X.2.2 For the purposes of classification, the following definitions apply**:**

Fuel cell system means fuel cell cartridge containing metal hydride and hydrogen, with or without fuel cell power unit as an electric generating device.
Fuel cell cartridge means the refillable receptacle containing metal hydride and hydrogen.
Fuel cell power unit means an electric generating device without a cartridge.

3X.3 Preparation of cartridge for testing

Cartridges shall be contained hydrogen of 95% or more of its designed capacity.

3X.4 Procedure

Each type of fuel cell system shall be individually subjected to Tests 1 through 3 in sequence on the same samples. Tests 4 through 6 should be conducted using not otherwise tested samples or undamaged samples previously used in Tests 1 through 3. Ten (10) representative samples of the same type of fuel cell system shall be tested.

3X.4.1 ***Test 1: Altitude Simulation***

3X.4.1.1 Purpose

This test simulates air transport under low-pressure conditions.

3X.4.1.2 Test procedure

Test samples of fuel cell system shall be stored at a pressure of 11.6 kPa or less for at least six hours at ambient temperature (20 ± 5°C).

3X.4.1.3 Requirement

Fuel cell system meets this requirement if there is no leakage after the test is performed.

3X.4.2 ***Test 2: Extreme temperature exposure***

3X.4.2.1 Purpose

This test assesses structure of fuel cell system and valve integrity using rapid and extreme temperature changes.

3X.4.2.2 Test procedure

Test samples of fuel cell system shall be stored for at least 2 hours at a test temperature of 75 ± 2°C, followed by storage for at least 2 hours at a temperature of - 40 ± 2°C. The maximum time interval between test temperatures extreme is 30 minutes. This procedure is to be repeated 10 times.

3X.4.2.3 Requirement

Fuel cell system meets this requirement if there is no leakage after the test is performed.

3X.4.3 Test 3: Vibration test

3X.4.3.1 Purpose

This test simulates vibration during transport.

3X.4.3.2 Test procedure

Test sample of fuel cell system is firmly secured to the platform of the vibration machine without distorting the fuel cell system in such a manner as to faithfully transmit the vibration. The vibration shall be a sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the fuel cell system.

The logarithmic frequency sweep is as follows: from 7Hz a peak acceleration of 1 g_n is maintained until 18Hz is reached. The amplitude is then maintained at 0.8mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8 g_n occurs (approximately 50 Hz). A peak acceleration of 8 g_n is then maintained until the frequency is increased to 200 Hz.

3X.4.3.3 Requirement

Fuel cell system meets this requirement if there is no leakage after the test is performed.

3X.4.4 Test 4: Drop test

3X.4.4.1 Purpose

This test simulates possible impacts to a fuel cell system during transport.

3X.4.4.2 Test procedure

Prior to conducting the drops, 5 of the samples shall be stored for at least 2 hours at 50 ± 2°C, and 5 of the samples shall be stored for at least 2 hours at -18 ± 2°C. Test sample of fuel cell system is dropped from a height of 1.5 m onto a rigid (e.g. concrete) surface in three orientations: valve up, valve down and horizontal. Three separate drops shall be conducted on each sample.

3X.4.4.3 Requirement

Fuel cell system meets this requirement if there is no leakage after the test is performed.

3X.4.5 *Test 5: Crush (compressive loading) test*

3X.4.5.1 Purpose

This test simulates possible crushing force applied to a fuel cell system.

3X.4.5.2 Test procedure

Test samples of fuel cell system are to be placed between two flat wooden blocks of approximately 250 mm long, 100 mm wide and 13 mm thick. The crushing force is to be applied to the exposed surfaces of the enclosure gradually at a rate of 13 mm/minute. Each force applicator is to exert 980N(100kgf) on the sample for one minute. Test samples are divided into two groups; 5 tested on the wide side and 5 tested on the narrow side. Each sample is to be subjected to only a single crush. Separate samples are to be used for each crush.

3X.4.5.3 Requirement

Fuel cell system meets this requirement if there is no leakage or mass of loss after the test is performed.

3X.4.6 Test 6: Expansion test

3X.4.6.1 Purpose

This test simulates possible combinations of stresses from the hydrogen gas pressure, the alloy expansion, particle fragmentation phenomena and the particle density growth due to vibration applied to a fuel cell system.

3X.4.6.2 Test procedure

Test samples of fuel cell system shall be tested with one hundred (100) cycles of absorption and release of hydrogen between 95% and 5% of designed capacity at ambient temperature of 20±5℃. The vibration according to Test 3 shall be performed at every twenty cycles at the state that hydrogen is released completely from a fuel cell system. The vibrations shall be exerted in the direction where metal hydride powder is considered to most easily move to result in uneven packing.

3X.4.6.3 Requirement

The distortion generated in a fuel cell system shall not exceed elastic deformation. And with cycles of filling and releasing hydrogen, distortion generated in a fuel cell system shall tend to cease to become constant. There is no leakage after the test is performed.”

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