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

Thirty-sixth session
Geneva, 30 November to 9 December 2009
Item 4 of the provisional agenda

ELECTRIC STORAGE SYSTEMS

Dual Electrical and Chemical Properties Matrix

Transmitted by RECHARGE and PRBA

Introduction

1. During the thirty-fifth session of the Sub-Committee, it was discussed by several members that perhaps fuel cell cartridges, ultracapacitors and batteries could be dealt with in a special section of the Model Regulations. This discussion took place as a result of the presentation of a working document prepared by the US Fuel Cells Council under the reference ST/SG/AC.10/C.3/2009/26 "Consolidation of energy systems into new section(s) of the UN Model Regulations on the Transport of Dangerous Goods".

2. During a lunchtime working group meeting RECHARGE agreed to prepare a Matrix comparing the dual electrical and chemical hazard properties of three types of Energy Storage Systems. The results of the comparative analysis are presented in Table 1 (p5) and Table 2 (p6) below and are further summarised in Table 3 (p7).

The analysis presented below concerns the properties of articles (goods) offered for transportation and not the properties originated in the use of these articles.

1. What is the meaning of "dual electrical and chemical properties" ?

3. The so-called dual electrical and chemical properties find their origin in the possibility of energy storage devices to release their chemical energy content under the form of electricity when designed accordingly.

4. In an article storing electrical energy, an internal or an external short-circuit may lead to high current flow through the article or through the external circuit.

5. The electrical current flow originates in the quantity of energy stored in the article and the way it is released. The electrical current flow leads to an elevation of

temperature by Joule Effect where the total power delivered by the system is proportional to the square (exponent) of the current flow.

JOULE EFFECT J = (I^2 x R x t) / 4.18 in cal /sec

2. Results of the Analysis

6. In Table 1, the information regarding the classification of Fuel Cells Cartridge and of Ultracapacitors is presented.

2.1. Fuel Cells Cartridges.

7. Fuel Cells can be defined as a source of electrical energy generated by direct conversion of chemical energy. The UN numbers reported in the 16th UN Model Regulations Chapter 3.2. Dangerous Goods List (listed in Table 1) are covering **Fuel Cells Cartridges** and are not representative of Fuel Cells.

8. The Cartridge does not store energy in an electrical form and a cartridge does not produce electrical energy by itself.

2.2. Ultracapacitors

9. A capacitor is a source of electrical energy generated by the accumulation of charges at the interfaces of a dielectric (the device accumulates electric charges at the interface between two conductors isolated by a dielectric (non-conductive substance or material).

10. After charging, the ultracapacitor is able to supply electrical current to an external device (without conversion of the chemical energy of its constituents).

11. Ultracapacitors being transported in a discharged status, the hazard that can be identified during transportation is related to the physico-chemical properties of the substances used in the sealed container. In a discharged state, the capacitor does not store electrical energy.

2.3. Batteries.

12. A battery is defined as a source of electrical energy generated by direct conversion of chemical energy. The batteries listed in the UN Model Regulation are classified as Class 9, Class 4.3 and Class 8 dangerous goods.

13. For the purposes of this analysis, the batteries have been separated into four categories: batteries “WET”, batteries “DRY”, lithium batteries and others. They are presented in Table 2.

14. In Table 2A, the batteries classified as “WET”, are filled with either acid or alkali electrolytes.

15. In Table 2B, the types of batteries classified as “DRY” are representatives of a battery that is shipped **de-activated**. Examples of such batteries include UN3028 (Batteries containing potassium hydroxide, solid) and the Sodium Battery UN 3292. The former battery does not contain any solvent when shipped and is not active. The latter is transported de-activated as the sodium is solid and not active at room temperature. The activation of the battery requires to raising its temperature well above 100°C.

16. In Table 2C, two types of Lithium batteries are reported; they have active materials confined in a sealed container and are classified under UN 3081 and 3481.

17. The recently classified Nickel-Metal Hydride battery is reported in Table 2D, This battery type has also active materials contained in a sealed container.

18. There are two conclusions that can be drafted out of this analysis on batteries.

(a) De-activated and discharged batteries offered for transportation do not present any potential combination of electrical and chemical properties.

(b) Other batteries offer such potential dual properties according to the state of charge of the individual battery. When a battery is in a charge state, an external short-circuit may occur when individual cells or batteries are not packaged in accordance with the regulation.

Conclusions

19. From this analysis one can conclude that the 3 categories of articles under consideration do not offer the common function of the delivery of electrical energy by direct transformation of chemical energy. In Table 3, the conclusions of this analysis are summarised.

1. A fuel cell cartridge does not store energy in an electrical form and the cartridge does not produce electrical energy by itself.

2. An ultra-capacitor transported in a discharge state does not offer the dual properties under consideration and the possibility of a combination of electrical and chemical hazards.

3. Under the generic term «Batteries» there is a need to distinguish between “activated/de-activated” batteries on one side and “charged/discharged” batteries on the other.

3.1. De-activated batteries do not present any potential risk of dual electrical and chemical properties when offered for transportation. Such batteries are the DRY battery described under UN 3028 and the SODIUM Battery under UN 3292.

3.2. Other batteries when transported in a discharge state do not present any dual electrical and chemical properties.

3.3. Batteries transported in a charge state may present such dual properties when they are subject to short-circuit during transportation.

4. Therefore, based on the the above analysis we do not recommend modifying the current UN classification. This current regulatory scheme is appropriate to cover the different hazards during transportation of the various articles covered by this study.

* * *

TABLE 1

"Dual Chemical and Electrical Properties" of Fuel Cell Cartridges and Ultra-Capacitors

CLASS	UN Nb	Name & Description	MAIN COMPONENTS IN ARTICLE	CHEMICAL HAZARD(S)	ELECTRICAL HAZARD(S)	DUAL CHEM. & ELECT. HAZARD(S)
	TABLE 1 FUEL CELL CARTRIDGE containing			STORAGE OF CHEMICALS		
3	3473	Flammable Liquids	1) OUTER CASING, INTERNAL COMPONENTS (E.G., A VALVE) 2) FUEL (LIQUID, SOLID OR GAS) AND SOMETIMES AN ACTIVATOR	LIQUIDS, GASES OR SOLIDS CONTAINED IN SEALED ARTICLE	NONE (CARTRIDGES STORE ENERGY AS A FUEL and NOT IN ELECTRICAL FORM) (CARTRIDGES DO NOT PRODUCE ELECTRICAL ENERGY BY THEMSELVES)	NO COMBINED EFFECT
4.3	3476	Water Reactive Substances				
8	3477	Corrosive Substances				
2.1	3478	Liquified Flammable Gas				
2.1	3479	Hydrogen in metal hydride				
	TABLE 1 ULTRACAPACITORS				STORAGE	
9	UN XXXX	TBD / ULTRACAPACITORS	1) METALLIC OUTER CASING, INTERNAL COMPONENTS 2) ORGANIC SOLVENT (FLAMMABLE OR NONDANGEROUS LIQUID) 3) ACTIVATED CARBON (NONDANGEROUS) 4) IONIC SALT AS AN ION SOURCE	ORGANIC SOLVENT ABSORBED IN A NONDANGEROUS SOLID CONTAINED IN SEALED ARTICLE IONIC SALT CONCENTRATION GENERALLY AROUND 1M IN SOLVENT	NONE – TRANSPORTED IN DISCHARGED STATE	NO COMBINED EFFECT

TABLE 2

"Dual Chemical and Electrical Properties" of Batteries.

CLASS	UN Nb	Name & Description	MAIN COMPONENTS IN ARTICLE	CHEMICAL HAZARD(S)	ELECTRICAL HAZARD(S)	DUAL CHEM. & ELECT. HAZARD(S)
	TABLE 2A BATTERIES WET					
8	2794	Filled with Acid, Electric Storage	1) METALLIC OR PLASTIC OUTER CASING 2) METALS, METALLIC OXIDES AND CHEMICALS,	NATURE OF METALS, OXIDES AND CHEMICALS, CONTAINED IN ARTICLE	DEPENDS ON STATE OF CHARGE – MAY BE TRANSPORTED CHARGED OR DISCHARGED	POTENTIAL COMBINED EFFECT - ONLY IN CHARGED STATE
8	2795	Filled with Alkali, Electric Storage				
8	2800	Non Spillable, Electric Storage				
	TABLE 2B BATTERIES DRY and BATTERIES SODIUM (De-activated)					
8	3028	Containing Potassium Hydroxide, solid, electric storage	1) METALLIC OR PLASTICS OUTER CASING 2) CHEMICALS POTASSIUM HYDROXIDE SOLID	SOLIDS CONTAINED IN ARTICLE	NONE – (CANNOT PRODUCE ELECTRICAL ENERGY IN ABSENCE OF SOLVENT)	NO COMBINED EFFECT
4.3	3292	Containing Sodium or Cells Containing Sodium	1) METALLIC OUTER CASING 2) SODIUM IN SOLID FORM 3) SOLID SEPARATOR	SOLIDS CONTAINED IN SEALED ARTICLE	NONE – (CANNOT PRODUCE ELECTRICAL ENERGY IN CONDITION TRANSPORTED) - ONLY OPERATES AT HIGH TEMPERATURE	NO COMBINED EFFECT

CLASS	UN Nb	Name & Description	MAIN COMPONENTS	CHEMICAL HAZARD(S)	ELECTRICAL HAZARD(S)	DUAL CHEM. & ELECT. HAZARD(S)
	TABLE 2C BATTERIES LITHIUM					
9	3090	Lithium Metal (inc. Lithium Alloys)	1) METALLIC OR PLASTIC OUTER CASING, INTERNAL COMPONENTS (E.G., THERMAL FUSES, DIODES, CIRCUITRY) 2) METALS, OXIDES CARBON AND CHEMICALS, ORGANIC SOLVENT & IONIC SALT AS A CHARGE CARRIER	LITHIUM METAL, OXIDES, CHEMICALS, ORGANIC SOLVENTS CONTAINED IN SEALED ARTICLES	TRANSPORTED IN CHARGED STATE or DISCHARGED WHEN SPENT	POTENTIAL COMBINED EFFECT - IN CHARGED STATE ONLY
9	3480	Lithium Ion (incl. Lithium Polymer)		INTERCALATED LITHIUM ION in GRAPHITE, OXIDES, ORGANIC SOLVENTS CONTAINED IN SEALED ARTICLES	DEPENDS ON STATE OF CHARGE – MAY BE TRANSPORTED CHARGED OR DISCHARGED	POTENTIAL COMBINED EFFECT ONLY IN CHARGED STATE - NO COMBINED EFFECT IN DISCHARGED STATE
	TABLE 2D BATTERIES (others)					
9	3496	Nickel-Metal Hydride	1) METALLIC OUTER CASING 2) METALS, CHEMICALS, ALLOYS, in WATER	SOLIDS + SOLVENT CONTAINED IN SEALED ARTICLE	DEPENDS ON STATE OF CHARGE – MAY BE TRANSPORTED CHARGED OR DISCHARGED	POTENTIAL COMBINED EFFECT ONLY IN CHARGED STATE & UNDER HIGH TEMPERATURE > 80°C EXPOSURE

TABLE 3
Summary of the Analysis
"Dual Chemical and Electrical Properties"
of Fuel Cell Cartridges, Ultra-Capacitors and Batteries

Articles	Chemical Properties	Electrical Properties	Dual (Electrical & Chemical)
Fuel Cell Cartridges	According to chemical and physical properties of Fuel	None	None
UltraCapacitors (Discharged)	According to chemical and physical properties of metals and chemicals contained in	None	None
Batteries discharged < 10 %) or de-activated	According to chemical and physical properties of metals and chemicals contained in	None (or restricted according to state of charge)	None or limited
Batteries (Charged)	According to chemical and physical properties of metals and chemicals contained in	Yes when Charged	Yes