United Nations ST/SG/AC.10/C.3/2010/33

Secretariat

Distr.: General
31 March 2010

Original: English

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-seventh session
Geneva, 21–30 June 2010
Item 4 of the provisional agenda
Electric storage systems

Transport requirements for ultracapacitors (Electric Double Layer Capacitors)

Transmitted by the Kilo Farad International (kFI)[1]

Introduction

1. At the last session, Kilo Farad International (kFI) submitted a proposal for a new proper shipping name for ultracapacitors with the objective of defining transport requirements specific to these energy storage devices.

2. In particular, kFI seeks to establish transport requirements specific to ultracapacitors to:

- Establish measures to avoid electrical short circuiting;
- Define appropriate transport requirements;
- Identify a size range not subject to the Model Regulations; and
- Identify requirements applicable to ultracapacitors in equipment.

I. Ultracapacitor description

3. Detailed descriptions of ultracapacitors were provided in earlier kFI documents, particularly ST/SG/AC.10/C.3/2009/13. Briefly, ultracapacitors are energy storage devices

[1] In accordance with the programme of work of the Sub-Committee for 2009-2010 approved by the Committee at its fourth session (refer to ST/SG/AC.10/C.3/68, para. 118 (a) and ST/SG/AC.10/36, para. 14).

that are being used increasingly in response to growing interest in energy conservation and reduction of green-house gas emissions. One of the many applications is in automobiles where they are used to store the electricity produced by regenerative braking systems. They are ideal for applications where there is a need to store and release energy quickly. In other instances, they are an alternative to batteries (e.g., in wind turbines) in view of their reliability and long life.

4. Ultracapacitors consist of two layers of activated carbon mixed with an electrolyte separated by a membrane. All but a small excess (a few ml) of electrolyte is absorbed by the activated carbon. The layers are frequently rolled up in a “jelly roll” and housed in a cylindrical aluminium receptacle. Currently, electrolyte liquids in common use consist either of a solution of approximately 70% acetonitrile mixed with inorganic salts or a non dangerous organic liquid (polypropylene carbonate) combined with salts. Ultracapacitors utilizing other electrolyte solutions are believed to be in the design stage but are not commercially available.

II. Discussion of potential hazards

A. Electrical hazard

5. Considering the majority of the electrolyte is absorbed and the robust construction of the ultracapacitor receptacle, kFI considers the electrical hazard to be the primary hazard. The hazard is related to the potential to accidentally short circuit in transport. This hazard is common to utracapacitors independent of the electrolyte used. For this reason kFI recommends establishment of minimum requirements for all ultracapacitors.

6. Unlike some other electric energy devices, there is no need to keep ultracapacitors or ultracapacitor modules in a charged condition. kFI proposes that ultracapacitors be required to be transported uncharged. To verify and ensure they are uncharged, we propose that the terminals on ultracapacitors with a capacitance greater than 100 Farad, be electrically connected by a conductive material.

7. This is impracticable for small ultracapacitors with a capacitance of 100 Farad or less and, for these ultracapacitors, we propose that they be protected against short circuit.

8. kFI anticipates that it should be possible to transport most ultracapacitors in equipment in an uncharged state. However, at least one vehicle manufacturer has indicated that it would be impractical to ensure that ultracapacitors installed in a vehicle are discharged when offered for transport. For ultracapacitors in equipment, we propose that they also be transported discharged and otherwise that they be protected against short circuiting.

B. Flammable liquid hazard

9. As noted, some ultracapacitors contain an electrolyte mixture of acetonitrile (approximately 70%) and inorganic salts. The salts are non combustible and reduce the heat content relative to pure acetonitrile. The electrolyte solution is absorbed onto activated carbon. Manufacturers typically include a small excess amount of electrolyte (ranging up to 6 ml for the largest currently available) to ensure complete wetting of the activated carbon. The ultracapacitor casing is robust to withstand any potential pressure build up over the life of the ultracapacitor as discussed below. kFI proposes that ultracapacitors containing dangerous goods be subject to a 1.2 meter drop test as packaged for transport to demonstrate the ability to retain their contents.

C. Pressure hazard.

10. There is no measurable pressure inside a new ultracapacitor. But pressure may build up over the useful life. The amount of pressure depends on the operating temperature and the charge voltage over the life of the ultracapacitor. There is no appreciable build up if an ultracapacitor is maintained at 25ºC and charged at its rated voltage. The relationship between pressure build up and charging voltage is illustrated in the following graph.

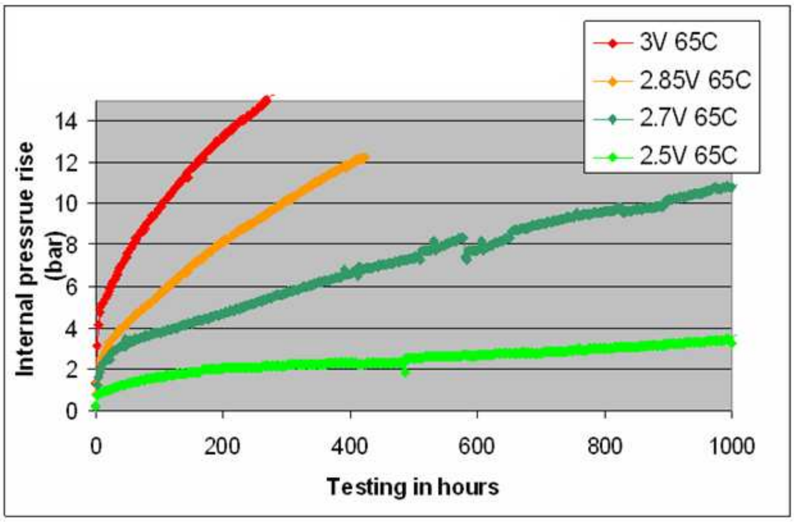
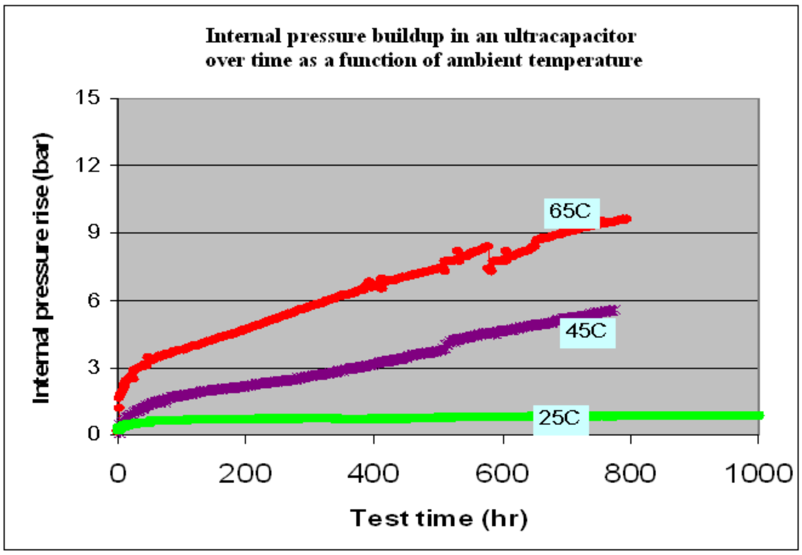


Figure shown above: Internal pressure buildup in an ultracapacitor over time at 65°C temperature as a function of operating voltage

11. The relationship between pressure buildup and temperature at the rated charge voltage (2.7 V) is illustrated in the following graph.



12. The air space volume in an ultracapacitor represents approximately 3% of the total volume of the ultracapacitor receptacle. For the current largest ultracapacitor design of 10 kF, the amount of free space is less than 10 ml. Even though the pressure inside the ultracapacitor may attain 15 bar over the life of the ultracapacitor under adverse conditions, the amount of stored energy is minimal. To address pressure concerns, an ultracapacitor is

either fitted with a vent or a weak point is built into the ultracapacitor receptacle so that it fails safely. To demonstrate the minimal risk posed by pressure buildup, kFI has prepared a series of videos that will be shared with Sub-Committee participants.

13. To address the concern for pressure buildup, kFI recommends a requirement indicating that ultracapacitors must be designed to safely relieve pressure.

III. KFI's proposed approach in considering options for regulating ultracapacitors

14. It is kFI’s opinion that ultracapacitors that meet certain requirements addressing the potential hazards described above should be permitted to be transported without having to meet all of the requirements generally applicable to dangerous goods. Applicable requirements should deal with the potential for short circuiting, retention of the electrolyte within the ultracapacitor receptacle and safe control of potential pressure build up. On this basis, kFI’s proposal is to apply these conditions to all ultracapacitors containing dangerous goods but to except those with a capacitance of less 10 kF or less (the maximum size limit currently produced) from other requirements of the UN Model Regulations. For ultracapacitors with no dangerous goods, kFI would propose to except them from other requirements if the electrical hazard and the hazard of potential pressure build up is addressed. KFI considers the risks associated with transporting ultracapacitors to be considerably lower than those for non spillable batteries (UN2800) which may be transported as non dangerous with no regard to size, no requirement to demonstrate integrity and are transported in a charged state provided the conditions in SP238 are met.

15. Based on comments, kFI proposes to use the proper shipping name, “CAPACITOR, electric double layer”. Hereafter in the discussion, the term capacitors refers to ultracapacitors or electric double layer capacitors (EDLC).

IV. Evaluation of options for regulating ultracapacitors

16. As agreed at the last meeting of the Sub-Committee, kFI has evaluated possible options for including requirements for capacitors in the United Nations Model Regulations. A number of possible approaches were considered based on discussions to date. These options are described and advantages and disadvantages are considered in the following paragraphs.

A. Option 1

17. Transport capacitors as Class 9 under the existing UN 3363 Dangerous Goods in Apparatus without amendment of SP 301. SP301 permits up to the limited quantity amount of electrolyte to be contained in apparatus. No changes to the recommendations are required.

Advantages

- Existing entry, no need to develop a new entry.
- The 1 liter limit on the amount of liquid permitted covers the full capacitor size range.

Disadvantages

- The short circuit risk is not addressed.
- Under ICAO there is a 0.5 liter liquid limit per package for UN 3363. The 0.5 liter limit accommodates existing capacitor designs when shipped as individual units. But amendments to accommodate capacitor modules with an aggregate quantity of liquid exceeding 0.5 liters are needed.
- All capacitors independent of size would be regulated, including capacitors installed in equipment (e.g., automobiles, wind turbines, aircraft doors).

B. Option 2

18. Revise SP 301 and transport capacitors as Class 9 under UN 3363 Dangerous Goods in Apparatus.

19. Under this option, SP301 would be amended by adding the following paragraph:

"Electric double layer capacitors, may be transported under this entry provided:

(a) They are transported in an uncharged state;

(b) Each capacitor or capacitor module is fitted with a metal strap connecting the terminals or for capacitors with a capacitance of 100 Farad or less, protected against short circuit;

(c) Capacitors installed in equipment are transported uncharged or protected against short circuiting; and

(d) Capacitors shall be designed to withstand a 95 kPa pressure differential and shall be designed to safely relieve any pressure buildup through a vent or a weak point in the receptacle.

Capacitors containing no dangerous goods, as indicated by a marking that states "No DG", and meeting the conditions in paragraphs (a) to (d) are not subject to other provisions of these Regulations.

Capacitors with a marked capacitance of 10 kF or less are not subject to other provisions of these Regulations when they meet the conditions in paragraphs (a) to (d) and withstand a 1.2 meter drop test as packaged for transport.".

Advantages

- Existing entry, no need to develop a new entry, minimal changes to the Special Provision.
- Capacitors of all sizes are accommodated.
- The short circuit risk and pressure buildup risk are addressed, irrespective of the electrolyte used.

Disadvantages

- The presence of flammable liquid is not communicated by the assigned class in the case of capacitors containing flammable liquid electrolyte.

C. Option 3

20. Introduce a new entry in Class 9 for capacitors.

21. The new table entry would read as follows:

(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
XXXX	CAPACITOR, electric double layer	9			AAA	None	E0	P003			

22. The accompanying special provision AAA would read:

"AAA This entry applies to energy storage devices known as Electric Double Layer Capacitors (EDLCs). EDLCs transported under this entry must meet the following conditions:

(a) They are transported in an uncharged state;

(b) Each capacitor or capacitor module is fitted with a metal strap connecting the terminals or for capacitors with a capacitance of 100 Farad or less, protected against short circuit;

(c) Capacitors installed in equipment are transported uncharged or protected against short circuiting; and

(d) Capacitors shall be designed to withstand a 95 kPa pressure differential and shall be designed to safely relieve any pressure buildup through a vent or a weak point in the receptacle**.**

Capacitors containing no dangerous goods, as indicated by a marking that states "No DG", and meeting the conditions in paragraphs (a) to (d) are not subject to other provisions of these regulations.

Capacitors with a marked capacitance of 10 kF or less are not subject to other provisions of these regulations when they meet the conditions in paragraphs (a) to (d) and are capable of withstanding a 1.2 meter drop test as packaged for transport.".

Advantages

- The short circuit risk and pressure buildup risk are addressed, irrespective of the electrolyte used.
- Assignment to class 9 is consistent with treatment of other equipment or apparatus containing small amounts of dangerous goods.
- Capacitors of all sizes are accommodated.

Disadvantages

- The presence of flammable liquid is not communicated by the assigned class in the case of capacitors containing flammable liquid electrolyte.

D. Option 4

23. Introduce new entries for capacitors for each class of electrolyte used and a separate entry in Class 9 for capacitors containing non dangerous electrolyte.

24. Currently, entries in Class 3 and 9 would be needed. Future additional entries for other classes (e.g., Class 8) may also be needed. New requirements for a class 3 entry would be as follows:

(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
XXXX	CAPACITOR, electric double layer, containing flammable liquid electrolyte	3			AAA	None	E0	P003			

25. The accompanying special provision AAA would read:

"AAA This entry applies to energy storage devices known as Electric Double Layer Capacitors (EDLCs). EDLCs transported under this entry must meet the following conditions:

(a) They are transported in an uncharged state;

(b) Each capacitor or capacitor module is fitted with a metal strap connecting the terminals or for capacitors with a capacitance of 100 Farad or less, protected against short circuit;

(c) Capacitors installed in equipment are transported uncharged or protected against short circuiting; and

(d) Capacitors shall be designed to withstand a 95 kPa pressure differential and shall be designed to safely relieve any pressure buildup through a vent or a weak point in the receptacle**.**

Capacitors with a marked capacitance of 10 kF or less are not subject to other provisions of these Regulations when they meet the conditions in paragraphs (a) to (d) and are capable of withstanding a 1.2 meter drop test as packaged for transport.".

26. New requirements for a class 9 entry would be as follows:

(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
YYYY	CAPACITOR, electric double layer, containing non dangerous electrolyte	9			BBB	None	E0	P003			

27. The accompanying special provision BBB would read:

"BBB This entry applies to energy storage devices known as Electric Double Layer Capacitors (EDLCs). EDLCs transported under this entry must meet the following conditions:

(a) They are transported in an uncharged state;

(b) Each capacitor or capacitor module is fitted with a metal strap connecting the terminals or for capacitors with a capacitance of 100 Farad or less, protected against short circuit;

(c) Capacitors installed in equipment are transported uncharged or protected against short circuiting; and

(d) Capacitors shall be designed to withstand a 95 kPa pressure differential and shall be designed to safely relieve any pressure buildup through a vent or a weak point in the receptacle.

Capacitors containing no dangerous goods, as indicated by a marking that states "No DG", and meeting the conditions in paragraphs (a) to (d) are not subject to other provisions of these regulations.

Advantages

- Places ultracapacitors in the class that reflects the hazard of the electrolyte.
- Addresses the short circuit and pressure buildup risk regardless of electrolyte used.

Disadvantage

- Approach is not consistent with the approach taken for UN3363 which allows small quantities of dangerous goods in machinery or apparatus to be treated as Class 9.
- Requires more entries and special provisions.
- While the provisions of the class 9 entry would apply, the entry itself would not normally appear on transport documents.

V. KFI evaluation of options

28. KFI believes that option 1 does not provide an adequate level of safety and should be rejected. The other three options provide an equivalent level of safety. While we can agree with any of these options, options 2 and 3 appear to be most consistent with the treatment of other machinery and apparatus where small quantities of dangerous goods are involved. This is not the case with option 4. Considering that in the future a new entry for asymmetric capacitors will be needed, kFI recommends option 3.

VI. KFI Proposal

29. KFI recommends that the Sub-Committee adopt the proposal given in option 3.

30. KFI also proposes the following consequential amendment to the table in paragraph 1.2.2.1:

Farad	F	-	1F = Ampere x s/V