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 **18 June 2024**

Sixty-fourth session
Geneva, 24 June-3 July 2024
Item 4 (b) of the provisional agenda
Electric storage systems:
Hazard-based system for classification of lithium batteries

Hazard-based system for classification of lithium batteries

Transmitted by the experts from Belgium and France and by the Advanced Rechargeable and Lithium Batteries Association (RECHARGE) on behalf of the informal working group

This informal document INF.26 is a revised version of official document ST/SG/AC.10/C.3/2024/13. Proposed amendments to the initial text are marked in red colour (see pages 18 ff).

I. Introduction

1. At its sixty-second session the Sub-Committee welcomed the work progress made by the informal working group on hazard-based classification of lithium batteries and cells, and agreed to go forward with a two-step approach:

(a) Finalize the hazard classification for the *Model Regulations* and the test protocol for the *Manual of Tests and Criteria*, including the drafting of amendments; and

(b) Develop the transport conditions for each hazard category, taking into account the assessment at a reduced state of charge and the conditions related to packaging.

2. The informal working group has continued its work and has achieved enough progress to offer some drafted text for presentation to the sub-committee.

3. This drafted text is not yet fully completed; it does mainly cover the points related to the classification itself, the procedure for testing cells and batteries in the manual, some special provisions and associated documentation and hazard communication issues. Following a two steps approach, further topics, like packing instructions, testing of cells or batteries in packaging, or testing of packaging will be addressed later.

4. New provisions have been added following the principle that the existing prescriptions shall not be substantially changed to stay inside the terms of reference. This work allows identifying some existing prescriptions that may be improved, but the informal working group preferred to leave the decision to the Sub-Committee. Furthermore, it was preferred not to make the process too complicated by mixing the different types of amendments. However, some experts in the informal working group felt that the transition measures in the current 2.9.4 (a) (new 2.9.4.1 (a)) are obsolete and could be deleted. Therefore, they appear in brackets in the proposal.

5. This drafted text also takes into account sodium ion cells and batteries as well. These articles were only introduced in the twenty-third revised edition of the *Model Regulations* (2023). As the terms of reference of the informal working group have been adopted before, sodium ion cells and batteries were not taken into account. On the other hand, those articles, although usually less reactive than lithium batteries, are regulated in a similar way. Furthermore, if the classification scheme for lithium cells and batteries were to be adopted, it would be unfair not to do so for sodium ion cells and batteries as these articles would

necessarily all be assigned by default to the most severe hazard division (9.X) and could not benefit of any exemption associated to lower hazard divisions.

6. The informal working group discussed the inclusion of sodium ion batteries in the classification scheme presented and noted sufficient support, although not unanimous, for their inclusion. This issue is left to the decision of the Sub-Committee.

7. The proposed testing and classification system allows identifying nine categories of cells and batteries. For clarity, the proposed hazard divisions range from 94A to 94H and 94X for lithium cells and batteries, and 95A to 95H and 95X for sodium cells and batteries.

8. Many new UN numbers are systematically proposed for cells and batteries according to these new hazard divisions, which appear in the drafted modifications of the list of dangerous goods in chapter 3.2. For clarity, these numbers range from UN 4000 to UN 4031 for lithium batteries and from UN 4100 to 4115 for sodium ion batteries, but the Sub-Committee may decide to adopt another numbering.

9. The decision concerning the number of hazard categories to keep, the decision to merge them or not in a unique set for both lithium and sodium ion cells and batteries and their final numbering, and the final number of new UN numbers needed is still open and will depend on the specific transport conditions which will be adopted later. However, for the moment, the draft includes all the possibilities.

10. Some points contain options such as:

(a) the indication of the category on placards or labels,

(b) the way to deal with batteries or cells that were not able to initiate a first thermal runaway when performing the propagation test,

(c) the possibility to classify a battery according to cells classification in some case, and

(d) some value not yet decided.

11. In these cases some comments have been introduced at the appropriate place in upper case letters. The informal working group will continue to investigate these points on the basis of the Sub-Committee's advices.

12. In order to facilitate the reading, the modified parts (paragraphs, sections, tables, special provisions or packing instructions) are reproduced completely (new text appears underlined and deleted text is stricken through).

13. This first draft provided in conformity with the terms of reference, allows getting a good picture of what the new system for classification could look like once introduced in the *Model Regulations* and the *Manual of Tests and Criteria*. The Sub-Committee is invited to comment, as appropriate, to allow the informal working group to continue its work toward a final proposal.

II. Proposals

14. Amendments to the following sections, paragraphs, special provisions and packing instructions are shown as follows (new text appears underlined and deleted text is ~~stricken through~~).

A. Proposed amendments to the *Model Regulations*

Chapter 2.9

2.9.2 Assignment to Class 9

Lithium cells and batteries

3090 and 4000 to 4007 LITHIUM METAL BATTERIES (including lithium alloy batteries)

3091 and 4016 to 4023 LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT (including lithium alloy batteries) or

3091 and 4016 to 4023 LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries)

3480 and 4008 to 4015 LITHIUM ION BATTERIES (including lithium ion polymer batteries)

3481 and 4024 to 4031 LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT (including lithium ion polymer batteries or

3481 and 4024 to 4031 LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)

3536 LITHIUM BATTERIES INSTALLED IN CARGO TRANSPORT UNIT

NOTE: *See 2.9.4.*

Sodium ion batteries

3551 and 4100 to 4107 SODIUM ION BATTERIES with organic electrolyte

3552 and 4108 to 4115 SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or

3552 and 4108 to 4115 SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte

2.9.4 Lithium cells and batteries

2.9.4.1 General requirements

Cells and batteries, containing lithium in any form shall be assigned one of the entries described in 2.9.4.2 as appropriate. They may be transported under these entries if they meet the following provisions:

(a) Each cell or battery is of a type proven to meet the requirements of each test of the *Manual of Tests and Criteria*, Part III, sub-section 38.3, Revision 3, Amendment 1 or any later revision;

~~(a) Each cell or battery is of the type proved to meet the requirements of each test of the *Manual of Tests and Criteria*, Part III, sub-section 38.3~~

[Cells and batteries manufactured according to a type meeting the requirements of subsection 38.3 of the *Manual of Tests and Criteria*, Revision 3, Amendment 1 or any subsequent revision and amendment applicable at the date of the type testing may continue to be transported, unless otherwise provided in these Regulations.

Cell and battery types only meeting the requirements of the *Manual of Tests and Criteria*, Revision 3, are no longer valid. However, cells and batteries manufactured in conformity with such types before 1 July 2003 may continue to be transported if all other applicable requirements are fulfilled.]

COMMENT: THE TRANSITION PERIOD IN SQUARE BRACKETS MAY NOT BE NECESSARY ANYMORE

NOTE: *Batteries shall be of a type proven-to meet the testing requirements of the Manual of Tests and Criteria, part III, sub-section 38.3, irrespective of whether the cells of which they are composed are of a tested type.*

(b) Each cell and battery incorporates a safety venting device or is designed to preclude a violent rupture under conditions normally incident to transport;

(c) Each cell and battery is equipped with an effective means of preventing external short circuits;

(d) Each battery containing cells or series of cells connected in parallel is equipped with effective means as necessary to prevent dangerous reverse current flow (e.g., diodes, fuses, etc.);

(e) Cells and batteries shall be manufactured under a quality management programme that includes:

(i) A description of the organizational structure and responsibilities of personnel with regard to design and product quality;

(ii) The relevant inspection and test, quality control, quality assurance, and process operation instructions that will be used;

(iii) Process controls that should include relevant activities to prevent and detect internal short circuit failure during manufacture of cells;

(iv) Quality records, such as inspection reports, test data, calibration data and certificates. Test data shall be kept and made available to the competent authority upon request;

(v) Management reviews to ensure the effective operation of the quality management programme;

(vi) A process for control of documents and their revision;

(vii) A means for control of cells or batteries that are not conforming to the type tested as mentioned in (a) above;

(viii) Training programmes and qualification procedures for relevant personnel; and

(ix) Procedures to ensure that there is no damage to the final product.

NOTE: *In house quality management programmes may be accepted. Third party certification is not required, but the procedures listed in (i) to (ix) above shall be properly recorded and traceable. A copy of the quality management programme shall be made available to the competent authority upon request.*

(f) Lithium batteries, containing both primary lithium metal cells and rechargeable lithium ion cells, that are not designed to be externally charged (see special provision 387 of Chapter 3.3) shall meet the following conditions:

(i) The rechargeable lithium ion cells can only be charged from the primary lithium metal cells;

(ii) Overcharge of the rechargeable lithium ion cells is precluded by design;

(iii) The battery has been tested as a lithium primary battery;

(iv) Component cells of the battery shall be of a type proved to meet the respective testing requirements of the *Manual of Tests and Criteria*, part III, sub-section 38.3.

(g) Except for button cells installed in equipment (including circuit boards), manufacturers and subsequent distributors of cells or batteries manufactured after 30 June 2003 shall make available the test summary as specified in the *Manual of Tests and Criteria*, Part III, sub-section 38.3, paragraph 38.3.~~5~~7.

2.9.4.2 Divisions according to hazard categories

Cells and batteries are assigned to one of the divisions according to their hazard properties as defined in the following table. Cells and batteries are assigned to the division which corresponds to the results of the tests described in the *Manual of Tests and Criteria*, part III, sub-section 38.3.5 and 38.3.6.

The test procedures allow assessment of cells and batteries so that an appropriate division can be assigned. The general scheme for classification of cells and batteries (flow chart) is shown in Figure 38.3.6 of the *Manual of Tests and Criteria.*

The assigned division is valid as long as the cell or battery remains in conformity with the type tested.

Division	**Hazard description: cells or batteries that, when subjected to the test protocol of *Manual of Tests***	**UN Numbers for cells and batteries**	**UN numbers for cells and batteries transported in or**

	***and Criteria*, subsections 38.3.5 and 38.3.6 present the following hazards:**		**with an equipment**
94A	Thermal runaway propagation and fire	4000, 4008	4016, 4024
94B	Thermal runaway propagation, no fire, but gas explosion hazard	4001,4009	4017, 4025
94C	Thermal runaway propagation but no fire and no gas explosion hazard	4002, 4010	4018, 4026
94D	No thermal runaway propagation but fire	4003, 4011	4019, 4027
94E	No thermal runaway propagation, no fire but a gas volume hazard, and a temperature hazard	4004, 4012,	4020, 4028
94F	No thermal runaway propagation, no fire, no temperature hazard, but a gas volume hazard	4005, 4013	4021, 4029
94G	No thermal runaway propagation, no fire and no gas volume hazard, but temperature hazard	4006, 4014	4022, 4030
94H	No thermal runaway propagation, no fire, no gas volume hazard, and no temperature hazard.	4007, 4015	4023, 4031
94X *	No testing information available	3090, 3480	3091, 3481

* Cells and batteries not tested according to 38.3.5 and 38.3.6, including cells and batteries that are prototypes or low productions runs, as mentioned in special provision 310, or damaged or defective cells and batteries are assigned to classification code 94X.

2.9.5 Sodium ion batteries

2.9.5.1 General requirements

Cells and batteries, cells and batteries contained in equipment, or cells and batteries packed with equipment containing sodium ion, which are a rechargeable electrochemical system where the positive and negative electrode are both intercalation or insertion compounds, constructed with no metallic sodium (or sodium alloy) in either electrode and with an organic non aqueous compound as electrolyte, shall be assigned one of the entries described in 2.9.5.2 appropriate.

NOTE: *Intercalated sodium exists in an ionic or quasi-atomic form in the lattice of the electrode material.*

They may be transported under these entries if they meet the following provisions:

(a) Each cell or battery is of the type proved to meet the requirements of applicable tests of the *Manual of Tests and Criteria*, part III, subsection 38.3.

(b) Each cell and battery incorporates a safety venting device or is designed to preclude a violent rupture under conditions normally encountered during transport;

(c) Each cell and battery is equipped with an effective means of preventing external short circuits;

(d) Each battery containing cells or a series of cells connected in parallel is equipped with effective means as necessary to prevent dangerous reverse current flow (e.g., diodes, fuses, etc.);

(e) Cells and batteries shall be manufactured under a quality management program as prescribed under 2.9.4.1 (e) (i) to (ix);

(f) Manufacturers and subsequent distributors of cells or batteries shall make available the test summary as specified in the *Manual of Tests and Criteria*, part III, sub-section 38.3, paragraph 38.3.5.

2.9.5.2 Divisions according to hazard categories

Cells and batteries are assigned to one of the divisions according to their hazard properties as defined in the following table. Cells and batteries are assigned to the division which corresponds to the results of the tests described in the *Manual of Tests and Criteria*, part III, subsection 38.3.5 and 38.3.6.

The test procedures allow assessment of cells and batteries so that an appropriate division can be assigned. The general scheme for classification of cells and batteries (flow chart) is shown in figure 38.x of the *Manual of Tests and Criteria*.

The assigned division is valid as long as the cell or battery remains in conformity with the type tested.

Division	**Hazard description: cells or batteries that, when subjected to the test protocol of the *Manual of Tests and Criteria* subsections 38.3.5 and 38.3.6 present the following hazards:**	**UN Numbers for cells and batteries**	**UN numbers for Cells and batteries transported in or with an equipment**
95A	Thermal runaway propagation and fire	4100	4108
95B	Thermal Runaway propagation, no fire, but gas explosion hazard	4101	4109
95C	Thermal runaway propagation but no fire and no gas explosion hazard	4102	4110
95D	No thermal runaway propagation but fire	4103	4111
95E	No thermal runaway propagation, no fire but gas volume hazard, and a temperature hazard	4104	4112
95F	No thermal runaway propagation, no fire, no temperature hazard, but a gas volume hazard	4105	4113
95G	No thermal runaway propagation, no fire and no gas volume hazard, but temperature hazard	4106	4114
95H	No thermal runaway propagation, no fire, no gas volume hazard, and no temperature hazard	4107	4115
95X *	No testing information available	3551	3552

* Cells and batteries not tested according to 38.3.5 and 38.3.6, including cells and batteries that are prototypes or low productions runs, as mentioned in special provision 310, or damaged or defective cells and batteries are assigned to classification code 95X.

2.9.6 Transport of batteries under a specific state of charge

Cells and batteries assigned to a category based on testing according to 2.9.4.2 or 2.9.5.2, conducted at a specific state of charge may be offered for transport according to the requirements of this category provided:

(a) The consignor demonstrates or ensures through instrumentation, physical process, documentation, inventory control or similar capability and quality management system mentioned in 2.9.4.1 (e) that the cells/batteries offered for transport do not exceed the state of charge used to determine the category;

(b) The transport document identifies the maximum state of charge of the cells or batteries (see 5.4.1.5.14); and

(c) The test summary includes conditions related to the categorization when the cell or battery is offered at a specific state of charge.

Chapter 3.2, List of dangerous goods

UN No.	Name and description	Class or division	Subsi-diary hazard	UN packing group	Special provi-sions	Limited and excepted quantities		Packagings and IBCs		Portable tanks and bulk containers	
								Packing instruction	Special packing provisions	Instruc-tions	Special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
-	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.2.5 / 4.3.2	4.2.5
3090	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94X			188 230 310 376 377 384 387	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906			
3091	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries)	94X			188 230 310 360 376 377 384 387 390	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906			
3480	LITHIUM ION BATTERIES (including lithium ion polymer batteries)	94X			188 230 310 348 376 377 384 387	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906			
3481	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94X			188 230 310 348 360 376 377 384 387 390	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906			
4000	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94A			188 384 387						
4001	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94B			188 384 387						
4002	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94C			188 384 387						
4003	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94D			188 384 387						
4004	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94E			188 384 387						
4005	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94F			188 384 387			PXXX			
4006	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94G			188 384 387			PXXX			
4007	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94H			188 384 387			PXXX			
4008	LITHIUM ION BATTERIES (including lithium ion polymer batteries	94A			188 384 387						
4009	LITHIUM ION BATTERIES (including lithium ion polymer batteries	94B			188 384 387						

UN No.	Name and description	Class or division	Subsi-diary hazard	UN packing group	Special provi-sions	Limited and excepted quantities		Packagings and IBCs		Portable tanks and bulk containers	
								Packing instruction	Special packing provisions	Instruc-tions	Special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
-	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.2.5 / 4.3.2	4.2.5
4010	LITHIUM ION BATTERIES (including lithium ion polymer batteries	94C			188 384 387						
4011	LITHIUM ION BATTERIES (including lithium ion polymer batteries)	94D			188 384 387						
4012	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94E			188 384 387						
4013	LITHIUM ION BATTERIES (including lithium ion polymer batteries)	94F			188 384 387			PXXX			
4014	LITHIUM METAL BATTERIES (including lithium alloy batteries)	94G			188 384 387			PXXX			
4015	LITHIUM ION BATTERIES (including lithium ion polymer batteries)	94H			188 384 387			PXXX			
4016	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries)	94A			188 384 387 390						
4017	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries	94B			188 384 387 390						
4018	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries	94C			188 384 387 390						
4019	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries	94D			188 384 387 390						
4020	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries	94E			188 384 387 390						
4021	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries	94F			188 384 387 390			PXXX			
4022	LITHIUM METAL	94G			188			PXXX			

UN No.	Name and description	Class or division	Subsi-diary hazard	UN packing group	Special provi-sions	Limited and excepted quantities		Packagings and IBCs		Portable tanks and bulk containers	
								Packing instruction	Special packing provisions	Instruc-tions	Special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
-	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.2.5 / 4.3.2	4.2.5
	BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries				384 387 390						
4023	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries	94H			188 384 387 390			PXXX			
4024	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94A			188 384 387 390						
4025	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94B			188 384 387 390						
4026	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94C			188 384 387 390						
4027	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94D			188 384 387 390						
4028	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94E			188 384 387 390						
4029	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94F			188 384 387 390			PXXX			
4030	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)	94G			188 384 387 390			PXXX			
4031	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM	94H			188 390			PXXX			

UN No.	Name and description	Class or division	Subsi-diary hazard	UN packing group	Special provi-sions	Limited and excepted quantities		Packagings and IBCs		Portable tanks and bulk containers	
								Packing instruction	Special packing provisions	Instruc-tions	Special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
-	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.2.5 / 4.3.2	4.2.5
	ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)										
3551	SODIUM ION BATTERIES with organic electrolyte	95X			188 230 310 348 376 377 384 400 401	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906			
3552	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95X			188 230 310 348 360 376 377 384 400 401	0	E0	P903 P908 P909 P910 P911 LP903 LP904 LP905 LP906			
4100	SODIUM ION BATTERIES with organic electrolyte	95A			188 230 376 377 384 387 400						
4101	SODIUM ION BATTERIES with organic electrolyte	95B			188 230 376 377 384 387 400						
4102	SODIUM ION BATTERIES with organic electrolyte	95C			188 230 376 377 384 387 400						
4103	SODIUM ION BATTERIES with organic electrolyte	95D			188 230 376 377 384 347 400						
4104	SODIUM ION BATTERIES with organic electrolyte	95E			188 230 376 377 384 387 400						

UN No.	Name and description	Class or division	Subsi-diary hazard	UN packing group	Special provi-sions	Limited and excepted quantities		Packagings and IBCs		Portable tanks and bulk containers	
								Packing instruction	Special packing provisions	Instruc-tions	Special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
-	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.2.5 / 4.3.2	4.2.5
4105	SODIUM ION BATTERIES with organic electrolyte	95F			188 230 376 377 384 387 400			PXXY			
4106	SODIUM ION BATTERIES with organic electrolyte	95G			188 230 376 377 384 387 400			PXXX			
4107	SODIUM ION BATTERIES with organic electrolyte	95H			188 230 376 377 384 387 400			PXXX			
4108	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95A			188 230 376 377 384 387 400						
4109	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95B			188 230 376 377 384 387 400						
4110	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95C			188 230 376 377 384 387 400						
4111	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95D			188 230 384 376 377 387 400						
4112	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95E			188 230 384 387 376 377 400						
4113	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95F			188 230 376 377 384 387			PXXY			

UN No.	Name and description	Class or division	Subsi-diary hazard	UN packing group	Special provi-sions	Limited and excepted quantities		Packagings and IBCs		Portable tanks and bulk containers	
								Packing instruction	Special packing provisions	Instruc-tions	Special provisions
(1)	(2)	(3)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9)	(10)	(11)
-	3.1.2	2.0	2.0	2.0.1.3	3.3	3.4	3.5	4.1.4	4.1.4	4.2.5 / 4.3.2	4.2.5
					400						
4114	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95G			188 230 376 377 384 387 400			PXXY			
4115	SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or SODIUM ION BATTERIES PACKED WITH EQUIPMENT, with organic electrolyte	95H			188 230 376 377 384 387			PXXY			

Chapter 3.3 (Special provisions)

Amend the following special provisions (SP) as follows:

SP 188:

188 Cells and batteries offered for transport are not subject to other provisions of these Regulations if they meet the following:

(a) For a lithium metal or lithium alloy cell, the lithium content is not more than 1 g, and for a lithium ion or sodium ion cell, the watt-hour rating is not more than 20 Wh;

(b) For a lithium metal or lithium alloy battery the aggregate lithium content is not more than 2 g, and for a lithium ion or sodium ion battery, the watt-hour rating is not more than 100 Wh. Lithium ion and sodium ion batteries subject to this provision shall be marked with the watt-hour rating on the outside case, except lithium ion batteries manufactured before 1 January 2009;

(c) Each lithium cell or battery meets the provisions of 2.9.4.1 (a), (e), (f) if applicable and (g) or for sodium ion cells or batteries, the provisions of 2.9.5.1 (a), (e) and (f) shall apply;

(d) Cells and batteries, except when installed in equipment, shall be packed in inner packagings that completely enclose the cell or battery. Cells and batteries shall be protected so as to prevent short circuits. This includes protection against contact with electrically conductive material within the same packaging that could lead to a short circuit. The inner packagings shall be packed in strong outer packagings which conform to the provisions of 4.1.1.1, 4.1.1.2, and 4.1.1.5;

(e) Cells and batteries when installed in equipment shall be protected from damage and short circuit, and the equipment shall be equipped with an effective means of preventing accidental activation. This requirement does not apply to devices which are intentionally active in transport (radio frequency identification (RFID) transmitters, watches, sensors, etc.) and which are not capable of generating a dangerous evolution of heat. When batteries are installed in equipment, the equipment shall be packed in strong outer packagings constructed of suitable material of adequate strength and design in relation to the packaging's capacity and its intended use unless the battery is afforded equivalent protection by the equipment in which it is contained;

(f) Each package shall be marked with the appropriate ~~lithium or sodium~~ battery mark, as illustrated at 5.2.1.9;

NOTE: *Packages containing lithium batteries packed in conformity with the provisions of part 4, chapter 11, packing instructions 965 or 968, section IB of the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air that bear the mark as shown in 5.2.1.9 ~~(lithium~~ battery mark) and the label shown in 5.2.2.2.2, Model No.9A shall be deemed to meet the provisions of this special provision.*

This requirement does not apply to:

(i) packages containing only button cell batteries installed in equipment (including circuit boards); and

(ii) packages containing no more than four cells or two batteries installed in equipment, where there are not more than two packages in the consignment.

When packages are placed in an overpack, the lithium or sodium battery mark shall either be clearly visible or be reproduced on the outside of the overpack and the overpack shall be marked with the word "OVERPACK". The lettering of the "OVERPACK" mark shall be at least 12 mm high.

(g) Except when cells or batteries are installed in equipment, each package shall be capable of withstanding a 1.2 m drop test in any orientation without damage to cells or batteries contained therein, without shifting of the contents so as to allow battery to battery (or cell to cell) contact and without release of contents; and

(h) Except when cells or batteries are installed in or packed with equipment, packages shall not exceed 30 kg gross mass.

As used above and elsewhere in these Regulations, "lithium content" means the mass of lithium in the anode of a lithium metal or lithium alloy cell. As used in this special provision "equipment" means apparatus for which the cells or batteries will provide electrical power for its operation.

Separate entries exist for lithium metal batteries and lithium ion batteries to facilitate the transport of these batteries for specific modes of transport and to enable the application of different emergency response actions.

A single cell battery as defined in part III, sub-section 38.3.2.3 of the *Manual of Tests and Criteria* is considered a "cell" and shall be transported according to the requirements for "cells" for the purpose of this special provision.

SP 230:

230 Lithium cells and batteries may be transported under this entry if they meet the provisions of 2.9.4.1. Sodium ion cells and batteries may be transported under this entry if they meet the provisions of 2.9.5.1.

SP 310:

310 Cells or batteries from production runs of not more than 100 cells or batteries, or pre-production prototypes of cells or batteries when these prototypes are transported for testing, shall meet the provisions of 2.9.4.1 with the exception of 2.9.4.~~1~~ (a), (e) (vii), (f) (iii) if applicable, (f) (iv) if applicable and (g).

SP 328:

328 […] When lithium metal, lithium ion or sodium ion batteries are contained in the fuel cell system, the consignment shall be consigned under this entry and under the appropriate entries for UN 3091 LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT, UN 3481 LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT, UN numbers from 4016 to 4023 LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT (division 94A to 94H) or UN numbers from 4024 to 4031 LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT (division 94A to 94H) or UN 3552 SODIUM ION BATTERIES CONTAINED IN EQUIPMENT or UN numbers from 4108 to 4115 SODIUM ION BATTERIES CONTAINED IN EQUIPMENT (division 95A to 95H).

SP 363:

363 […] (f) Engines or machinery may contain other dangerous goods than fuels (e.g. batteries, fire extinguishers, compressed gas accumulators or safety devices) required for their functioning or safe operation without being subject to any additional requirements for these other dangerous goods, unless otherwise specified in these Regulations. However, lithium batteries shall meet the provisions of 2.9.4.1, except that 2.9.4.1 (a), (e) (vii), (f) (iii) if applicable, (f) (iv) if applicable and (g) do not apply when batteries of a production run of not more than 100 cells or batteries, or pre-production prototypes of cells or batteries when these prototypes are transported for testing, are installed in machinery or engines.

SP 377:

377 […] These cells and batteries are not subject to the requirements of section 2.9.4.1 or 2.9.5.1. Additional exemptions may be provided under the conditions defined by modal transport regulations. […]

SP 387:

387 Lithium batteries in conformity with 2.9.4.1 (f) containing both primary lithium metal cells and rechargeable lithium ion cells shall be assigned to ~~UN Nos. 3090 or 3091 as appropriate.~~ the UN number corresponding to the highest division of the component cells. If both kind of cells have the same category, it shall be assigned to the UN number corresponding to the lithium metal battery. When such batteries are transported in accordance with special provision 188, the total lithium content of all lithium metal cells contained in the battery shall not exceed 1.5 g and the total capacity of all lithium ion cells contained in the battery shall not exceed 10 Wh.

SP 388:

388 […] Examples of equipment are lawnmowers, cleaning machines or model boats and model aircraft. Equipment powered by lithium metal batteries or lithium ion batteries shall be assigned to one of the entries UN numbers from 4016 to 4023 LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT (division 94A to 94H) or UN numbers from 4024 to 4031 LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT (division 94A to 94H) or UN 3091 LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or UN 3091 LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT or UN 3481 LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or UN 3481 LITHIUM ION BATTERIES PACKED WITH EQUIPMENT, as appropriate. Lithium ion batteries or lithium metal batteries installed in a cargo transport unit and designed only to provide power external to the cargo transport unit shall be assigned to the entry UN 3536 LITHIUM BATTERIES INSTALLED IN CARGO TRANSPORT UNIT lithium ion batteries or lithium metal batteries.

Dangerous goods, such as batteries, airbags, fire extinguishers, compressed gas accumulators, safety devices and other integral components of the vehicle that are necessary for the operation of the vehicle or for the safety of its operator or passengers, shall be securely installed in the vehicle and are not otherwise subject to these Regulations. However, lithium batteries shall meet the provisions of 2.9.4.1, except that 2.9.4.1 (a), (e) (vii), (f) (iii) if applicable, (f) (iv) if applicable and (g) do not apply when batteries of a production run of not more than 100 cells or batteries, or pre-production prototypes of cells or batteries when these prototypes are transported for testing, are installed in vehicles or equipment. […]

SP 389:

389 This entry only applies to lithium ion batteries or lithium metal batteries installed in a cargo transport unit and designed only to provide power external to the cargo transport unit. The lithium batteries shall meet the requirements of 2.9.4.1 (a) to (g) and contain the necessary systems to prevent overcharge and over discharge between the batteries. […]

SP 390:

390 When a package contains a combination of lithium batteries contained in equipment and lithium batteries packed with equipment, the following requirements apply for the purposes of package marking and documentation:

(a) the package shall be marked "UN 3091 Lithium metal batteries packed with equipment", or "UN 3481 Lithium ion batteries packed with equipment", or "UN numbers from 4016 to 4023 LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (division 94A to 94H)" or "UN numbers from 4024 to 4031 LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (division 94A to 94H)" as appropriate. If a package contains both lithium ion batteries and lithium metal batteries packed with and contained in equipment, the package shall be marked as required for both battery types. However, button cell batteries installed in equipment (including circuit boards) need not be considered.

(b) the transport document shall indicate "UN 3091 Lithium metal batteries packed with equipment" or "UN 3481 Lithium ion batteries packed with equipment" or "UN numbers from 4016 to 4023 LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (division 94A to 94H)" or "UN numbers from 4024 to 4031 LITHIUM ION BATTERIES PACKED WITH IN EQUIPMENT (division 94A to 94H)", as appropriate. If a package contains both lithium metal batteries and lithium ion batteries packed with and contained in equipment, then the transport document shall indicate both "UN 3091 Lithium metal batteries packed with equipment" or "UN numbers from 4016 to 4023 LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (division 94A to 94H)" and "UN 3481 Lithium ion batteries packed with equipment" or "UN numbers from 4024 to 4031 LITHIUM ION BATTERIES PACKED WITH IN EQUIPMENT (division 94A to 94H)".

Chapter 4 1

- In 4.1.4.1, ultimately, new packing instructions are to be defined, such as:

(1) packing instruction PXXX concerning:

UN 4007 (division 94H, UN 4004 (Division 94 E), UN 4005 (division 94F) and UN 4006 (division 94G),

UN 4015 (division 94H, UN 40012 (Division 94 E), UN 4013 (division 94F) and UN 4014 (division 94G),

UN 4023 (division 95H), UN 4020 (Division 95 E), UN 4021 (division 94F) and UN 4022 (division 94G), and

UN 4031 (division 94H), UN 4028 (Division 95 E), 4029 (division 94F) and UN 4030 (division 94G).

~~PXXX PACKING INSTRUCTION PXXX~~

(2) packing instruction PXXY concerning:

UN 4101 (division 94A, UN 4105 (division 95F) and UN 4106 (division 95G)?), and

UN 4108 (division 95H) (also UN 4113 (division 95F) and UN 4114 (division 95G)?).

PXXY PACKING INSTRUCTION PXXY

PXXY	**PACKING INSTRUCTION**	**PXXY**
TO BE FURTHER DEFINED BY THE INFORMAL WORKING GROUP		
Special packing provisions: **PPXY:**		

Chapter 5.2

5.2.2.2.1.3 With the exception of labels for divisions 1.4, 1.5 and 1.6 of Class 1, the upper half of the label shall contain the pictorial symbol and the lower half shall contain the class or division number 1, 2, 3, 4, 5.1, 5.2, 6, 7, 8 or 9 as appropriate. However, for label model No. 9A, the upper half of the label shall only contain the seven vertical stripes of the symbol and the lower half shall contain the group of batteries of the symbol and the division number 94X or 94A to 94H, or 95X or 95A to 95H. Except for label model No. 9A, the label may include such text as the UN number, or words describing the hazard class (e.g. "flammable") in accordance with 5.2.2.2.1.5 provided that the text does not obscure or detract from the other required label elements.

COMMENT: IN THE CASE THE OPTION TO MENTION THE DIVISION ON THE LABELS IS ACCEPTED THE TABLE OF SPECIMENT LABELS NEEDS TO BE MODIFIED ACCORDINGLY.

Chapter 5.4

Add the following new paragraph:

5.4.1.5.14: *Transport of a battery at a specific state of charge (SOC)*

When batteries are transported in accordance with 2.9.4.3, the transport document shall identify the maximum state of charge authorized for transport.

B. Proposed amendments to the *Manual of Test and Criteria*

The detailed test conditions are still being validated through testing, and additional modifications to the test protocol are possible.

Amendments to subsection 38.3

38.3 Lithium metal , lithium ion and sodium ion cells and batteries

38.3.1 ***Purpose***

This section presents:

(a) the procedures to be followed for the classification of lithium metal and lithium ion and sodium ion cells and batteries (see 2.9.4 and 2.9.5 of the *Model Regulations* ~~see UN Nos. 3090, 3091, 3480 and 3481, and the applicable special provisions of Chapter 3.3 of the Model Regulations~~) as described in 38.3.2, 38.3.3 and 38.3.4; and;

(b) the procedure to be followed for the categorization of the lithium metal and lithium ion cells and batteries according to their hazard~~. A~~ as described in 38.3.5 and 38.3.6.

The cells and batteries tested in accordance with the following procedures may be assigned one of the UN Nos. described in 2.9.4.2 or 2.9.5.2, depending on the test results.

Note: *In this section the words « sodium in cells or batteries » refer to sodium ion with organic electrolyte cells or batteries.*

38.3.2 ***Scope***

38.3.2.1 All lithium cell types shall be subjected to tests T.1 to T.6 and T.8. as defined in 38.3.3 and 38.3.4. All non-rechargeable lithium battery types, including those composed of previously tested cells, shall be subjected to tests T.1 to T.5. All rechargeable lithium battery types, including those composed of previously tested cells, shall be subjected to tests T.1 to T.5 and T.7. In addition, rechargeable single cell lithium batteries with overcharge protection shall be subjected to test T.7. A component lithium cell that is not transported separately from the battery it is part of needs only to be tested according to tests T.6 and T.8. A component cell that is transported separately from the battery shall be subjected to tests T.1 to T.6 and T.8. A cell or battery that is an integral part of the equipment it is intended to power that is transported only when installed in the equipment, may be tested in accordance with the applicable tests when installed in the equipment. To allow categorization according to 2.9.4.2, lithium cell and battery types may be subjected to the tests defined in 38.3.5 and 38.3.6.

All sodium ion cell types shall be subjected to tests T.1 to T.6. All rechargeable sodium ion battery types, including those composed of previously tested cells, shall be subjected to tests T.1 to T.5 and test T.7. In addition, rechargeable single cell sodium ion batteries with overcharge protection shall be subjected to test T.7. A component sodium ion cell that is not transported separately from the battery it is part of needs only to be tested according to tests T.6. A component sodium ion cell that is transported separately from the battery shall be subjected to tests T.1 to T.6. A sodium ion cell or battery that is an integral part of the equipment it is intended to power that is transported only when installed in the equipment, may be tested in accordance with the applicable tests when installed in the equipment. To allow categorization according to 2.9.5.2, sodium ion cell and battery types may be subjected to the tests defined in 38.3.5 and 38.3.6.

38.3.2.2 Lithium metal lithium ion and sodium ion cells and batteries shall be subjected to the tests, as required by special provisions 188 and, (230) and XXX of Chapter 3.3 2.9.4 and 2.9.5. of the *Model Regulations* prior to the transport of a particular cell or battery type.

Cells or batteries which differ from a tested type by:

(a) For primary cells and batteries, a change of more than 0.1 g or 20 % by mass, whichever is greater, to the cathode, to the anode, or to the electrolyte;

(b) For rechargeable cells and batteries, a change in nominal energy in Watt-hours of more than 20 % or an increase in nominal voltage of more than 20 %; or

(c) A change that would lead to failure of any of the tests

shall be considered a new type and shall be subjected to the required tests of 38.3.4.

NOTE*: The type of change that might be considered to differ from a tested type, such that it might lead to failure of any of the test results, may include, but is not limited to:*

(a) A change in the material of the anode, the cathode, the separator or the electrolyte;

(b) A change of protective devices, including hardware and software;

(c) A change of safety design in cells or batteries, such as a venting valve;

(d) A change in the number of component cells;

(e) A change in connecting mode of component cells; and

(f) For batteries which are to be tested according to T.4 with a peak acceleration less than 150 g_n, a change in the mass which could adversely impact the result of the T.4 test and lead to a failure.

In the event that a cell or battery type does not meet one or more of the test requirements, steps shall be taken to correct the deficiency or deficiencies that caused the failure before such cell or battery type is retested.

Cells and batteries which differ from a tested type by a change in the design that would lead to a change in the result of any of the tests defined in 38.3.5 and 38.3.6 shall be subject to a new testing to benefit the classification.

38.3.2.3 For the purposes of classification, the following definitions apply:

[…]

State-of-charge (SOC) means the percentage of the rated capacity contained in a cell or a battery as measured by subjecting it to a load, temperature and voltage cut-off point specified by the manufacturer.

NOTE: *see note of the "rated capacity" definition for measurement methods.*

38.3.3 to **38.3.4**: *existing text unchanged*

38.3.5 Required tests for categorization

In order to determine a specific categorization of the cell or battery, 3 repetitions of the tests corresponding to the categorization flowchart shall be run. If one of the tests cannot be completed and makes the hazard evaluation impossible, additional tests shall be run, until a total of 3 valid tests are completed.

Primary cells and batteries shall be tested undischarged. Rechargeable cells and batteries transported at a specific state of charge under 2.9.4.3 shall be tested at least at that state of charge.

When cells or batteries that have been tested through categorization tests (T.9 to T.11) are electrically connected, the assembled battery may be assigned to the division of tested component cells or batteries without retesting if the assembled battery is of a type that has been verified as preventing ***any adverse effect related to the battery assembly when compared to the cell hazard.***

Note: ~~Examples of mechanisms that may have an adverse effect include~~ Examples of design characteristics that may result in an impact to battery categorization may include, but are not limited to:

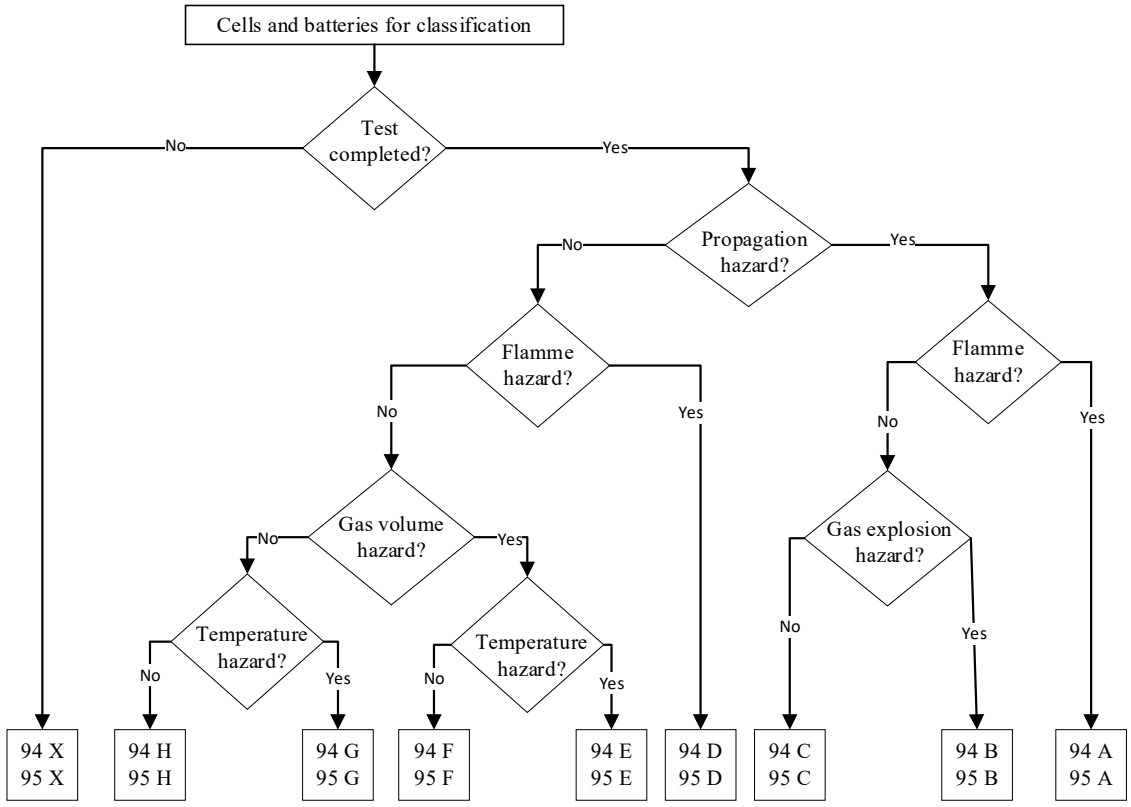
- ***Overcurrent, overcharge or overdischarge of any cell or group of cells in case of one cell in the battery is suddenly short-circuited***
- ***Battery material changing thermal emissions and/or thermal transfer***
- ***Tabs connection causing large heat transfer***

A specific test or a calculation based on the battery configuration (number of cells in series and in parallel) may be used for the purpose of this verification.

38.3.6 Procedure for categorization tests (T.9 to T.11)

The divisions of 2.9.4.2. and 2.9.5.2. of the *Model Regulations* are defined according to the following flowchart. Cells and batteries are assigned to one of these divisions which corresponds to the results of the tests performed according to the following procedures.

Figure 38.3.6 : Classification criteria for lithium metal, lithium ion and sodium ion cells and batteries



The most severe hazard measured over the 3 valid tests shall be reported as the cell or battery test results.

The proposed tests for the hazard classification system are based on forcing the initiation cell into thermal runaway through the application of heat on the surface of a cell or a cell in a battery pack or module until the thermal runaway reaction is initiated inside the cell or the cell surface temperature has reached **375** °C.

COMMENT:FOR THE CELLS OR BATTERIES THAT WOULD NOT INITIATE A THERMAL RUNAWAY AT A FULLY CHARGED STATE OF CHARGE WHEN APPLYING THE TEST PROTOCOLS, THE INFORMAL WORKING GROUP WILL LOOK AT APPROPRIATE TRANSPORT CONDITIONS:

- *THE CELL OR THE BATTERY MAY BE ASSIGNED TO THE RELEVANT CATEGORY ACCORDING TO THE TEST RESULT (DIVISIONS 94F TO 94H OR 95F TO 95H); OR*
- *ALTERNATIVELY, SUCH CELLS MAY BE ELIGIBLE FOR TRANSPORT UNDER CONDITIONS AUTHORIZED BY COMPETENT AUTHORITIES, UNTIL THE REGULATION IS AMENDED TO ADDRESS THESE NON-REACTIVE TECHNOLOGIES (E.G. SOLID STATE BATTERIES). THE COMPETENT AUTHORITY MAY DECIDE UPON THE TRANSPORT CONDITION BASED ON A COMPLEMENTARY DOSSIER INCLUDING: THE DEMONSTRATION OF THE ABSENCE OF REACTION DURING THE UN TEST (PARTICULARLY CELL SHORT CIRCUIT AND CRUSHING) [AND AN ARC TEST UNTIL 400°C DEMONSTRATING THE ABSENCE OF REACTION OF THE CHEMISTRY USED].*

Note : When cells or batteries have been demonstrated as reactive during the test T9 by the presence of a thermal run-away at a high SOC, then the cells can be classified according to the test result at lower SOC, even in the absence of thermal runaway. ~~potential absence of thermal runaway at a lower SOC doesn't prevent their assignment in the relevant division~~

38.3.6.1 Test T.9: Cell propagation test

38.3.6.1.1. Purpose

The purpose of the test is to create a worst-case testing condition to assess the risk of thermal runaway propagation and, if applicable, the propagation rate from cell to cell,

the risk of flame generation in the case of thermal runaway of a cell or multiple cells and the maximum temperature of a of a cell or multiple cells in the case of thermal runaway.

38.3.6.1.2 Test procedure

The propagation test is conducted by placing 4 identical cells inside a thermally insulated test fixture designed to tightly maintain the 4 cells in a row. The initiation cell shall be placed at one end of the row, with the heater on the side of the initiation cell that is not adjacent to the next cell in the row. All other cells will be placed side by side, with the larger side used as the contact surface, or the longer side for cylindrical cells. There shall not be any material inserted between the cells. The quality of direct contact will be ensured by use of rigid test fixtures, or in the case of flexible material, by use of a compression force of the row of 1 kg force. The test fixture must have 6 sides to maximize heat containment. The test fixture shall have the required mechanical robustness to contain all mechanical ejections, including through the lid, but allow for gas and flame exhaustion. Additionally, the test lab could use various heating rates to avoid core ejection when possible. The distance between the cells and the lid shall be limited in a way to avoid complete potential cell core ejection, but leaving appropriate room for the gas exhaustion. The gas exhaust position shall be placed at the end of the row opposite to the initiation cell, and shall be of an appropriate size to prevent overpressure inside the test fixture. Each cell will be equipped with a thermocouple.

[The initiation cell shall be heated with a system/set-up/equipment enabling a heat transfer to the cell at an initial rate of [20 ± 2] Watts/cm^2 [other unit in W/mm^2/kg cell] [example of devices are heating wires, copper contact shapes, …]. The size of the contact surface between the cell and the device shall not exceed 20 % of the total cell surface for cylindrical cells, or 20 % of the face for prismatic and pouch cells. with a minimum of 10 mm^2]. The efficiency of the heat transfer shall be controlled by a thermocouple placed at 5± 2 mm of the side of the heating device.

i) As a result, the initiation cell should be heated at a rate of ***10*** ±***5*** ***°C per minute,*** , based on the measure of the control thermocouple.

ii) Alternatively, a higher heating rate could be applied for large cells . Based on the GTR20/ ISO6469-1 the heating rate should be minimum 15°C/second measured on the heater, with the necessary power to achieve the expected heating rate when respecting the heater size.

The large cells definition of the UN MT&C are applicable for the definition of the size.

The power of the heater shall be controlled manually or electronically to maintain the heating rate constant during the whole test duration. The heater power shall be cut off when a thermal runaway is detected (detection of a continuous increase of the temperature of the initiation cell without increase of the heater power for more than ***[3 minutes, ~~or at a rate of more than 1 °C/s over a 3 second period of time, TO BE AGREED UPON~~]***, or when the initiation cell temperature has reached 375 °C for at least 1 minute. The data are recorded for 6 hours after stopping power to the heater.

To detect flame the use of a video recording device is required to capture the potential appearance of flames. A flame detection is defined by the observation of a sustained flame, by opposition to sparks or a flash flame.

The maximum temperature determination is based on the use of a thermocouple on the last cell of the row. To capture the maximum temperature during the test the thermocouple will be placed on the surface of the cell that is furthest away from the initiation cell and insulated from any test fixture contact. The thermocouples shall be thermally protected against direct ambient gas temperature measurement.

38.3.6.1.3 Test criteria

Provided the lid remains in place, a partial core ejection or gas ejection would not invalidate the test.

(a) Propagation: the temperature of the cells in the row will be used to detect the propagation of the thermal runaway. The test will demonstrate the absence of propagation

when the 4th cell in the row does not experience thermal runaway. In the case of propagation, the time difference between two successive cells experiencing thermal runaway in the row (based on the detection of the maximum temperature reached by each cell) will be measured. The propagation time will be calculated based on the average of all the time differences measured during the 3 repetitions of the test. The test result is proposed to be expressed as either no propagation, or propagation.

(b) Flames: the video recording of the test will be analyzed to detect the presence of flames. The test result will be expressed as a cell property: the cell does generate fire or does not generate fire. A flame detection is defined by the observation of a sustained flame, by opposition to sparks or a flash flame.

(c) Temperature: the temperature recording of the cells during the test will be analyzed to detect the maximum temperature for a period of 3 minutes. The test result will be expressed as a cell property: maximum temperature observed during the test either exceeds a 150 °C increase above the temperature at the time the heater is stopped, or is below a 150 °C increase.

38.3.6.2 Test T.10: Cell gas volume determination

38.3.6.2.1 Purpose

The purpose of the test is to determine the quantity of gas generated in the case of thermal runaway of a cell. It is considered by default that all lithium cells generate toxic gas.

38.3.6.2.2 Test procedure

The test method used to determine the quantity of gas generated by a single cell in thermal runaway is based on capturing of the gas generated inside an enclosure, equipped either with a gas pressure and temperature measurement, or with a volumetric gauge.

The thermal runaway is initiated in a similar way as for the propagation test, except that it only applies to a single cell.

The chamber for gas volume measurement shall be a tight enclosure, filled with inert gas (nitrogen or argon) enabling to measure the gas volume released in absence of combustion. The chamber size will be determined based on the size of the cell, and the potential maximum volume of gas released.

The necessary time for temperature and pressure to stabilize and homogenize must be allowed before making the pressure and temperature measurements.

38.3.6.2.1.3 Criteria

The result of the test will be expressed as a volume of gas in liters, at ambient temperature and normal pressure. The result could be expressed either as no gas volume measured, or gas volume below **25** liters, or gas volume above **25** liters. (rationale: The volume, with two adjustments, is based on the volume of lithium ion battery gas that if collected and ignited in a representative narrow-body aircraft Class C cargo compartment loaded to 70 % capacity could over pressure the compartment and dislodge the decompression panels. From testing that volume was determined to be 57 liters (see chapters 9 & 10 of "Summary of FAA Studies…": see 2.2).

38.3.6.3 Test T.11: Battery propagation test

38.3.6.3.1 Purpose

The test purpose is to create a worst-case testing condition to assess the risk of thermal runaway propagation inside the battery, and from battery to battery.

38.3.6.3.2 Test procedure

The tests for the hazard classification are based on the initiation of the thermal

runaway of the battery, with the same heater initiation method as in T.9, applied to one cell inside the battery.

The selected cell should be the one providing more risk of propagation. Particularly, the selected cell should fulfill the following conditions, as far as applicable:

(a) be on a battery side, in a position enabling the application of the heater, or the alternative trigger method

(b) be at the shorter distance of neighboring cells, considering the general battery design, and

(c) be closer or better connected to thermal masses or cooling systems when compared to other cells, considering the general battery design.

In the cases where the application of the heater requires the opening of a hard casing, the opening should be closed again while allowing external wiring, and prevent gas leakage as far as possible, in order to limit potential differences in the test result due to the opening (such as gas leakage).

In the cases where the application of a heater on a cell is not technically possible, or does interfere with the designed pack elements, especially the safety mechanisms, or the construction of the battery, other equivalent ignition methods may be applied (overcharge of one cell, overcharge of a module, use a laser, use specially prepared cells with internal short circuit system,-. …). Features of the battery like distance between elements, fire protections, plastic parts, gas venting channels and other similar features shall not be modified for the test. This alternative method would only be acceptable in the case it generates a thermal runaway reaction on the initiation cell.

Similarly to the T.9 test performed on cells, the initiation cell shall be heated at a rate of ***105 °C per minute,*** , based on the measure of the control thermocouple. The heater power shall be cut off when a thermal runaway is detected (detection of an increase of temperature slope without increase of the heater power for more than 3 minutes), or when the cell temperature has reached 350 °C for at least 1 minute.

The battery shall be equipped with external thermocouples on at least 3 surfaces of the battery, except the surface with the initiation cell. For placing the thermocouples, representative positions for the respective side of the battery should be selected, to represent the maximum measurable temperature of the surface of the battery.

In the case of batteries without casing, the thermocouples will be placed on the outer surface available (plastic sleeve or cell casing).

Only when applying the heated method on the surface of a cell or a cell in a battery pack or module for forcing the initiation cell into thermal runaway according to 36.3.6, the test can be stopped when the cell or the cell surface temperature has reached 375 °C without initiating a thermal runaway. If an alternative trigger method for the thermal runaway is applied, the cell must be at a temperature of 375 °C as well before stopping the test. Alternatively, a thermal runaway of the trigger cell must be initiated.

To detect flame the use of a video recording device is required to capture the potential appearance of flames at any of the gas exhausts of the thermally insulated test fixture.

38.3.6.3.3 Criteria

For temperature : the temperature recording of test will be analyzed to detect the maximum temperature for a period of ***3 minutes,***. The test result will be expressed as a battery property : the maximum temperature observed during the test either exceeds a 150 °C increase above the temperature at the time the heater or the alternative initiation method is stopped or is below a 150 °C increase.

For propagation: no surface temperature shall be above 100 °C except momentary spike below 200 °C.

For flames: the video recording of the test will be analyzed to detect the presence of flame. A flame detection is defined by the observation of a sustained flame, by opposition to sparks or a flash flame. The test result will be expressed as a battery property: battery does generate fire or does not generate fire.

38.3.6.3.4. Alternative test procedure T.11b.

Alternatively, a method using several batteries, similar to the cell propagation method, is applicable to verify the propagation risk between batteries in specific cases:

(a) in the case of batteries where the casing is hot or melting, but do not propagate the thermal runaway to a neighbor battery of the same type; and

(b) in the case of single cells batteries, or batteries without casing.

In the cases where the application of a heater on a cell is not technically possible, or does interfere with the designed pack elements, especially the safety mechanisms or the construction of the battery, other equivalent ignition methods may be applied, as described in the test procedure T11.

38.3.6.3.5. Criteria for the alternative method T.11b.

For temperature : the temperature recording of test will be analyzed to detect the maximum temperature for a period of ***3 minutes,***. The test result will be expressed as a battery property : the maximum temperature observed during the test either exceeds a 150 °C increase above the temperature at the time the heater or the alternative initiation method is stopped or is below a 150 °C increase.

For propagation: no propagation shall take place from battery to battery.

For flames: the video recording of the test will be analyzed to detect the presence of flame. A flame detection is defined by the observation of a sustained flame, by opposition to sparks or a flash flame. The test result will be expressed as a battery property: battery does or does not generate fire.

38.3.6.4. Test T.12: Battery gas volume determination

38.3.6.4.1. Purpose

The purpose of the test is to determine the quantity of gas generated in the case of thermal runaway of a cell or cells inside a battery. It is considered by default that all lithium battery cells generate toxic gas.

38.3.6.4.2. Test procedure

Two protocols are proposed for the determination of gas quantities:

(a) the test protocol applicable is exactly the same as for test T.10, that is the T.10 test is performed on only one cell of the battery. For the whole battery, the test result takes into account the number of cells that have reacted inside the battery during the propagation test T.11, when available, or

(b) when a single cell cannot be separated or made available from another source, then the test protocol of test T.10 is applied to the complete battery, the heater being applied to a single cell in the battery, or an alternative method as described in the test T11.

The chamber for gas volume measurement shall be similar to the one used for the cells classification test. ***[COMMENT: INVESTIGATE ACCEPTATION OF EQUIVALENT TEST EQUIPMENT?]***

38.3.6.4.3 Criteria

The result of the test will be expressed as a volume of gas in liters, at ambient temperature and normal pressure, calculated as follows :

(a) if a single cell has been tested, then the measured volume of gas shall be multiplied by the number of cells that have reacted during the thermal runaway propagation test of the battery, or by the total number of cells in the battery if no result for the propagation test is not available,

(b) if the test has been performed on the whole battery, the result of the test is the total measured volume of gas.

The result could be expressed as either no gas volume measured, or total gas volume below 25 liters, or total gas volume above 25 liters.

38.3.6.5. Test T.13: Cell gas flammability determination

38.3.6.5.1. Purpose

Not all lithium batteries exhibit flammability hazard. Testing to determine gas flammability is optional for assignment to either divisions 94B, 95B or 94C and 95C. If testing is not conducted then divisions 94B or 95B are assumed by default.

38.3.6.5.1.1 Test procedure

COMMENT: THE TESTING METHOD TO VERIFY GAS FLAMMABILITY IS UNDER DISCUSSION AMONGS THE IWG TESTING LABORATORY MEMBERS BASED ON THEIR SPECIFIC COMPETENCY CONDUCTING SUCH TESTS. IT WAS SUGGESTED USING STANDARD ISO 10156 WHICH SPECIFIES METHODS FOR DETERMINING WHETHER OR NOT A GAS OR GAS MIXTURE IS FLAMMABLE IN AIR AND WHETHER A GAS OR GAS MIXTURE IS MORE OR LESS OXIDIZING THAN AIR UNDER ATMOSPHERIC CONDITIONS, BASED ON TESTING OR CALCULATION.

38.3.6.5.1.2 Criteria

The result of the test will be expressed as a gas property for the tested cell: flammable or non-flammable gas.

38.3.~~7~~5 Cell and battery test summary

The following test summary shall be made available:

Cell or battery test summary in accordance with sub-section 38.3 of the *Manual of Tests and Criteria*
The following information shall be provided in this test summary : (a) Name of cell, battery, or product manufacturer, as applicable; (b) Cell, battery, or product manufacturer's contact information to include address, phone number, email address and website for more information; (c) Name of the test laboratory to include address, phone number, email address and website for more information; (d) A unique test report identification number; (e) Date of test report; (f) Description of cell or battery to include at a minimum: (i) Lithium ion, lithium metal or sodium ion cell or battery;

(ii) Mass of cell or battery;
(iii) Watt-hour rating, or lithium content;
(iv) Physical description of the cell/battery; and
(v) Cell or battery model number or, alternatively, if the test summary is established for a product containing a cell or battery, the product model number.

(g) List of mandatory tests conducted under 38.3.4 and results (i.e., pass/fail)

(h) If applied, list of tests conducted under 38.3.5 for categorization purpose;

(i) If applied, SOC at which the cell or battery was tested according to 2.9.4.3 ;

(j~~h~~) Reference to assembled battery testing requirements, if applicable (i.e. 38.3.3 (f) and 38.3.3 (g));

(k~~i~~) Reference to the revised edition of the *Manual of Tests and Criteria* used and to amendments thereto, if any; and

(l~~j~~) ~~Signature with~~ Name and title of responsible person ~~signatory~~ as an indication of the validity of information provided