



**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****Fiftieth session**

Geneva, 28 November-6 December 2016

Item 2 (d) of the provisional agenda

**Recommendations made by the Sub-Committee
on its forty-seventh, forty-eighth
and forty-ninth sessions and pending issues:
electric storage systems****Transport of damaged/defective lithium batteries, step I****Transmitted by the European Association for Advanced Rechargeable
Batteries (RECHARGE) and the International Organization of Motor
Vehicle Manufacturers (OICA)¹****Introduction**

1. The transport of damaged/defective lithium batteries is currently regulated in Special Provision 376. It allows two ways of transport, either “(A)” P908/LP904 for the transport of damaged/defective lithium batteries, non-reactive under normal transport conditions or “(B)” using a competent authority approval to transport damaged / defective lithium batteries liable to be reactive to induce dangerous events under normal transport conditions.
2. Because the composition of a standard packaging definition to transport such damaged/defective lithium batteries, liable to be reactive to induce dangerous events under normal transport conditions failed in the past, these batteries have to be transported via competent authority approval. The experience gained from given approvals and acquired during these transports should now help to define a general packaging performance standard.

¹ In accordance with the programme of work of the Sub-Committee for 2015–2016 approved by the Committee at its seventh session (see ST/SG/AC.10/C.3/92, paragraph 95 and ST/SG/AC.10/42, para. 15).

3. OICA members have examined several approvals given by competent authorities of different countries which indicate different transport solutions by using different packagings based on different testing and calculations methods (island solutions). They recognised many similarities, summarized and proposed them as a first working document (ST/SG/AC.10/C.3/2015/51) at the December 2015 session.
4. The outcome of the discussion at the December 2015 session was to discuss this technical issue at the 3rd session of the Informal Working Group on Lithium Batteries in Bordeaux in March/April 2016 for a technical review by the participating battery and packaging experts. The Sub-Committee provided a mandate to the Group to submit the outcome of this technical discussion at the Geneva meeting in June/July 2016.
5. In the context of this paper presentation (informal document INF.12, forty-ninth session) at the Geneva meeting in June/July and of the subsequent discussion, the delegates signaled that an improvement of the current transport regulations is important and that they will support this issue in general, because there is an urgent and increasing need for different branches of industry (packaging industry, cell and battery manufacturers as well as E-bike and car manufacturers, etc.) and because it is applicable for different battery sizes.
6. For transport safety it is important to have a clearly defined and applicable transport solution managing the carriage of all battery types on a larger scale (as proposed by the French and German experts) and this will support and disburden the competent authorities (as proposed by the Swiss expert), too.
7. As a possible future, innovative, practical and high safety transport solution applicable for all types of damaged/defective lithium batteries (A and B), a performance based packaging that would take account of the actual damage and/or defect, using mitigation and/or prevention measures (e.g. as currently discussed and developed by SAE Technical Standard G-27 Committee in the context of ICAO discussions on safe air transport of lithium batteries) was discussed, too.
8. Because of the time-consuming development of the necessary regulatory details (e.g. definition of a generally applicable testing procedure for different cells and batteries etc.) of such a performance based packaging and the integration into the Recommendations on the Transport of Dangerous Goods, this might not be a reachable goal in this biennium (a first attempt to show such a solution will be made in a further informal document to be discussed at the Sub-Committee).
9. Because there is an urgent and increasing need for a short term decision to transport these damaged/defective batteries (B) without competent authority approval, RECHARGE and OICA propose the following “step one” proposal on the basis of several current approvals given by competent authorities, the outcome of the technical discussion at the third meeting of the Informal Working Group on Lithium Batteries at Bordeaux, the comments received from the delegates of the Sub-Committee at the forty-eighth and forty-ninth sessions and from authorities, associations and industry. They propose also to promote the current discussion to achieve a performance based packaging as transport solution (“step two”).
10. The proposed regulatory and technical details are separated in:
 - (a) The revision of Special Provision 376 to archive:
 - (i) A clear distinction between the application of P908/LP904 and the new proposed P9XX/LP9XX or rather the competent authority approval (as proposed by the Swiss delegate),

- (ii) That for all types of transport (according to P908/LP904/P9XX/LP9XX) the packaging shall be marked with “DAMAGED/DEFECTIVE LITHIUM ION BATTERIES” or “DAMAGED/DEFECTIVE LITHIUM METAL BATTERIES”,
- (iii) That the transport document shall include a reference to the used packaging instruction, comparable to the revised Special Provision 310 and to several current competent authority approvals, which also include this requirement.
- (b) The revision of P908/LP904: to archive a correction of the introductory text of P908/LP904 and the inclusion of a clear definition when P908/LP904 is applicable (reference to Special Provision 376, as proposed by the Swiss delegate).
- (c) The introduction of the new P9XX/LP9XX with the following regulatory and technical details:
- (i) A reference to Special provision 376 with a clearly defined application of this new P9XX/LP9XX (as proposed by the Swiss delegate);
- (ii) A reference, that the used packaging shall meet the conditions of section 4.1.1 and 4.1.3 of the Model Regulations on the Transport of Dangerous Goods (as already known from different packaging instructions, e.g. current P908/LP904; as proposed by the German delegate);
- (iii) The use of a PG I performance level packaging on the basis of most of the current competent authority approvals (and as a logical consequence, because for the carriage of damaged/defective batteries, non-reactive under normal transport conditions according to P908/LP904, a PG II performance level packaging is applicable);
- (iv) The outside surface temperature of the completed package shall not have a temperature of more than 100°C, as already known from packing instruction P500 (UN3365, Oxygen Generator);
- (v) A momentary spike in temperature up to 200°C shall be acceptable, as already known from the Model Regulations on the Transport of Dangerous Goods sub-section 2.1.3.6.4 (a) for Class 1 articles;
- (vi) The packaging shall meet the criteria “no hazardous flame outside”, “no hazardous ejection fragments” and “no damage of the packaging” based on the current discussions on performance based packaging (e.g. at ICAO /SAE Technical Standard G-27 Committee), since this is seen as a further safe step towards a performance based packaging (bearing in mind that any other innovative solutions and packaging that cannot confirm will still have the option of obtaining a competent authority approval);
- (vii) That some kind of gas management is necessary (as proposed by the delegates of France and Germany) according to the current competent authority approvals and as specified in section 5.5.2 of the Model Regulations on the Transport of Dangerous Goods (special provisions applicable to fumigated cargo transport units (UN 3359));
- (viii) That the packaging performance shall be verified by a test or by a calculation method and the competent authority is responsible for the verification (test and/or calculation) details (the delegates of Germany, United States and France proposed that a detailed test and/or calculation method is necessary; a guideline with exemplary technical details is attached as an annex);

(ix) That the verification report shall be available on request with a minimum of cell/battery details, for a clear confirmability for competent authorities and operator);

(x) That in case of use of dry ice or liquid nitrogen as a coolant, the requirements specified in section 5.5.3 of the Model Regulations on the Transport of Dangerous Goods shall apply and the inner packaging and outer packaging shall maintain their integrity at the temperature of the refrigerant used as well as the temperatures and the pressures which could result if refrigeration were lost. These requirements are already known from packing instruction P650 (9) for UN3373 (Biological Substance, Category B).

Proposal

RECHARGE and OICA propose the revision of SP376, amendments to P908 and LP904 and the introduction of the new P9XX and LP9XX for the transport of damaged/defective lithium batteries liable to be reactive to induce dangerous events under normal transport conditions (B) without a competent authority approval as follows (changes to existing text underlined):

SP376

“Lithium ion cells or batteries and lithium metal cells or batteries identified as being damaged or defective such that they do not conform to the type tested according to the applicable provisions of the Manual of Tests and Criteria shall comply with the requirements of this special provision.

For the purposes of this special provision, these may include, but are not limited to:

- *Cells or batteries identified as being defective for safety reasons;*
- *Cells or batteries that have leaked or vented;*
- *Cells or batteries that cannot be diagnosed prior to transport; or*
- *Cells or batteries that have sustained physical or mechanical damage.*

NOTE: *In assessing a battery as damaged or defective, the type of battery and its previous use and misuse shall be taken into account.*

Cells and batteries shall be transported according to the provisions applicable to UN 3090, UN 3091, UN 3480 and UN 3481, except Special Provision 230 and as otherwise stated in this special provision.

Cells and batteries shall be packed in accordance with packing instructions P908 of 4.1.4.1 or LP904 of 4.1.4.3, as applicable.

Cells and batteries identified as damaged or defective and liable to rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of transport shall be transported in accordance with

packing instructions P9XX of 4.1.4.1 or LP9XX of 4.1.4.3

or

under conditions specified by the competent authority, as applicable.

Packages shall be marked “DAMAGED/DEFECTIVE LITHIUM ION BATTERIES” or

“DAMAGED/DEFECTIVE LITHIUM METAL BATTERIES”, as applicable.

The transport document shall include the following statement:

“Transport in accordance with special provision 376 (Packing Instruction as applicable)”.

P908	PACKING INSTRUCTION	P908
<p>This instruction applies to damaged or defective lithium ion cells and batteries and damaged or defective lithium metal cells and batteries, including those contained in equipment, of UN Nos. 3090, 3091, 3480 and 3481. <i>This instruction applies to damaged or defective cells and batteries of UN Nos. 3090, 3091, 3480 and 3481 not liable to rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of transport.</i></p>		
<p>The following packagings are authorized provided the general provisions of 4.1.1 and 4.1.3 are met:</p> <p>For cells and batteries and equipment containing cells and batteries:</p> <p style="padding-left: 40px;">Drums (1A2, 1B2, 1N2, 1H2, 1D, 1G);</p> <p style="padding-left: 40px;">Boxes (4A, 4B, 4N, 4C1, 4C2, 4D, 4F, 4G, 4H1, 4H2);</p> <p style="padding-left: 40px;">Jerricans (3A2, 3B2, 3H2).</p> <p>Packagings shall conform to the packing group II performance level.</p> <ol style="list-style-type: none"> 1. Each damaged or defective cell or battery or equipment containing such cells or batteries shall be individually packed in inner packaging and placed inside of an outer packaging. The inner packaging or outer packaging shall be leak- proof to prevent the potential release of electrolyte. 2. Each inner packaging shall be surrounded by sufficient non-combustible and non-conductive thermal insulation material to protect against a dangerous evolution of heat. 3. Sealed packagings shall be fitted with a venting device when appropriate. 4. Appropriate measures shall be taken to minimize the effects of vibrations and shocks, prevent movement of the cells or batteries within the package that may lead to further damage and a dangerous condition during transport. Cushioning material that is non-combustible and non-conductive may also be used to meet this requirement. 5. Non combustibility shall be assessed according to a standard recognized in the country where the packaging is designed or manufactured. <p>For leaking cells or batteries, sufficient inert absorbent material shall be added to the inner or outer packaging to absorb any release of electrolyte.</p> <p>A cell or battery with a net mass of more than 30 kg shall be limited to one cell or battery per outer packaging.</p>		
<p>Additional requirements: Cells or batteries shall be protected against short circuit.</p>		

LP904	PACKING INSTRUCTION	LP904
<p>This instruction applies to single damaged or defective batteries of UN Nos. 3090, 3091, 3480 and 3481, including those contained in equipment. <i>This instruction applies to damaged or defective single batteries of UN Nos. 3090, 3091, 3480 and 3481 not liable to rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of transport.</i></p>		
<p>The following large packagings are authorized for a single damaged or defective battery and for a single damaged or defective battery contained in equipment, provided the general provisions of 4.1.1 and 4.1.3 are met.</p>		
<p>For batteries and equipment containing batteries:</p> <ul style="list-style-type: none"> steel (50A) aluminium (50B) metal other than steel or aluminium (50N) rigid plastics (50H) plywood (50D) 		
<p>Packagings shall conform to the packing group II performance level.</p>		
<ol style="list-style-type: none"> 1. Each damaged or defective battery or equipment containing such a battery shall be individually packed in an inner packaging and placed inside of an outer packaging. The inner packaging or outer packaging shall be leak-proof to prevent the potential release of electrolyte. 2. Each inner packaging shall be surrounded by sufficient non-combustible and non-conductive thermal insulation material to protect against a dangerous evolution of heat. 3. Sealed packagings shall be fitted with a venting device when appropriate. 4. Appropriate measures shall be taken to minimize the effects of vibrations and shocks, prevent movement of the battery within the package that may lead to further damage and a dangerous condition during transport. Cushioning material that is non-combustible and non-conductive may also be used to meet this requirement. 5. Non combustibility shall be assessed according to a standard recognized in the country where the packaging is designed or manufactured. 		
<p>For leaking batteries, sufficient inert absorbent material shall be added to the inner or outer packaging to absorb any release of electrolyte.</p>		
<p>Additional requirements: Batteries shall be protected against short circuit.</p>		

P9XX	PACKING INSTRUCTION	P9XX
	<p><i>This instruction applies to damaged or defective cells and batteries of UN Nos. 3090, 3091, 3480 and 3481 liable to rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of transport.</i></p>	
	<p><i>The packagings conforming to (1) and (2) are authorized, provided that the general provisions of 4.1.1 and 4.1.3 are met.</i></p> <p><i>(1) The packagings shall conform to the packing group I performance level and meet the following requirements when the cells and batteries rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours:</i></p> <p style="padding-left: 40px;"><i>(a) The outside surface temperature of the completed package shall not have a temperature of more than 100°C. A momentary spike in temperature up to 200°C is acceptable,</i></p> <p style="padding-left: 40px;"><i>(b) No hazardous flame outside,</i></p> <p style="padding-left: 40px;"><i>(c) No hazardous ejection fragments,</i></p> <p style="padding-left: 40px;"><i>(d) No damage of the packaging.</i></p> <p><i>The packagings shall have a gas management system (e.g. filter system, air circulation, containment for gas, gas tight packaging etc.) capable to prevent any hazard in the environmental surrounding.</i></p> <p><i>(2) The packaging performance shall be verified by one of the following methods as specified by the competent authority:</i></p> <p style="padding-left: 40px;"><i>(a) Demonstration by a test: or</i></p> <p style="padding-left: 40px;"><i>(b) By a calculation corresponding to the maximum mass and energy of the cell/battery type as defined in the Manual of Tests and Criteria, paragraph 38.3.2.2, in the condition of transport.</i></p> <p style="padding-left: 40px;"><i>(c) The verification report shall be available on request. As a minimum requirement, the cell and battery name, the cell and battery number, the weight, type, energy content of the cells and batteries, the packaging identification and the test data according to the verification method as specified by the competent authority shall be listed in the verification report.</i></p> <p><i>(3) When dry ice or liquid nitrogen is used as a coolant, the requirements of section 5.5.3 shall apply. The inner packaging and outer packaging shall maintain their integrity at the temperature of the refrigerant used as well as the temperatures and the pressures which could result if refrigeration were lost.</i></p>	
	<p><i>Additional requirements:</i></p> <p><i>Cells and batteries shall be protected against short circuit.</i></p> <p><i>Protection against short circuits includes, but is not limited to:</i></p> <ul style="list-style-type: none"> <i>- individual protection of the battery terminals,</i> <i>- inner packaging to prevent contact between cells and batteries,</i> <i>- batteries with recessed terminals designed to protect against short circuits, or</i> <i>- the use of a non-conductive and non-combustible cushioning material to fill empty space between the cells or batteries in the packaging.</i> 	

LP9XX	PACKING INSTRUCTION	LP9XX
	<p><i>This instruction applies to single damaged or defective batteries of UN Nos. 3090, 3091, 3480 and 3481 liable to rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours under normal conditions of transport.</i></p>	
	<p><i>The large packagings conforming to (1) and (2) are authorized, provided that the general provisions of 4.1.1 and 4.1.3 are met.</i></p> <p><i>(1) The packagings shall conform to the packing group I performance level and meet the following requirements when the cells and batteries rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours:</i></p> <p style="margin-left: 40px;"><i>(a) The outside surface temperature of the completed package shall not have a temperature of more than 100°C. A momentary spike in temperature up to 200°C is acceptable,</i></p> <p style="margin-left: 40px;"><i>(b) No hazardous flame outside,</i></p> <p style="margin-left: 40px;"><i>(c) No hazardous ejection fragments,</i></p> <p style="margin-left: 40px;"><i>(d) No damage of the packaging.</i></p> <p><i>The packagings shall have a gas management system (e.g. filter system, air circulation, containment for gas, gas tight packaging etc.) capable to prevent any hazard in the environmental surrounding.</i></p> <p><i>(2) The packaging performance shall be verified by one of the following methods as specified by the competent authority:</i></p> <p style="margin-left: 40px;"><i>(a) Demonstration by a test: or</i></p> <p style="margin-left: 40px;"><i>(b) By a calculation corresponding to the maximum mass and energy of the cell/battery type as defined in the Manual of Tests and Criteria, paragraph 38.3.2.2, in the condition of transport.</i></p> <p style="margin-left: 40px;"><i>(c) The verification report shall be available on request. As a minimum requirement, the cell and battery name, the cell and battery number, the weight, type, energy content of the cells and batteries, the packaging identification and the test data according to the verification method as specified by the competent authority shall be listed in the verification report.</i></p> <p><i>(3) When dry ice or liquid nitrogen is used as a coolant, the requirements of section 5.5.3 shall apply. The inner packaging and outer packaging shall maintain their integrity at the temperature of the refrigerant used as well as the temperatures and the pressures which could result if refrigeration were lost.</i></p>	
	<p>Additional requirements: <i>Batteries shall be protected against short circuit.</i></p> <p><i>Protection against short circuits includes, but is not limited to:</i></p> <ul style="list-style-type: none"> <i>- individual protection of the battery terminals,</i> <i>- inner packaging to prevent contact between cells and batteries,</i> <i>- batteries with recessed terminals designed to protect against short circuits, or</i> <i>- the use of a non-conductive and non-combustible cushioning material to fill empty space between the cells or batteries in the packaging.</i> 	

Conclusion

RECHARGE and OICA propose the regulatory changes of Special Provision 376, P908 and LP904 as specified above and the introduction of the new P9XX and LP9XX for a future safe transport of

(a) Damaged/defective lithium batteries, liable to be reactive to induce dangerous events under normal transport conditions (A) corresponding to P908/LP904; and

(b) Damaged/defective lithium batteries, reactive under normal transport conditions (B) according to P9XX/LP9XX or with a competent authority approval

as a clearly defined improvement of the current transport regulations.

Annex

To verify the performance of the packaging the competent authority may apply the following criteria, as applicable, to the test conditions and/or the calculation method:

(a) *The test and calculation shall be done under a quality management system (as described e.g. in section 2.9.4. (e)) allowing for the traceability of tests results, reference data and characterization models used.*

(b) *The list of hazards expected in case of thermal runaway of the battery type, in the condition it is transported [e.g. usage of an inner packaging, SOC, usage of sufficient non-combustible, non conductive and absorbent cushioning material etc.], shall be clearly identified and quantified: the reference list of possible hazards for Lithium batteries (rapidly disassemble, dangerously react, produce a flame or a dangerous evolution of heat or a dangerous emission of toxic, corrosive or flammable gases or vapours) can be used for this purpose. The quantification of this hazard shall rely on available scientific literature*

(c) *The mitigations effects of the packaging shall be identified and characterized, based on the nature of the protections provided and the construction material properties. A list of technical characteristics and drawings shall be used to support this assessment (Density [$\text{kg}\cdot\text{m}^{-3}$], specific heat capacity [$\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$], heating value [$\text{kJ}\cdot\text{kg}^{-1}$], thermal conductivity [$\text{W}\cdot\text{m}^{-1}\cdot\text{K}^{-1}$], melting temperature and flammability temperature [K], heat transfer coefficient of the outer packaging [$\text{W}\cdot\text{m}^{-2}\cdot\text{K}^{-1}$], ...)*

(d) *The supporting test or calculation shall assess the result of the thermal run-away of the battery inside the packaging in the representative conditions of transport.*

(e) *In case the SOC (state of charge) of the battery is not known, the assessment used shall be done with the higher possible state of charge corresponding to the battery usage conditions.*

(f) *The surrounding conditions in which the packaging may be transported shall be described (including possible consequences of gas or smoke emissions on the environment).*

(g) *The tests or the model calculation shall consider the worst case scenario for the thermal runaway triggering and propagation inside the battery: this scenario includes the worst possible failure mode in the transport condition, the maximum heat and flame emissions for the possible propagation of the reaction.*

(h) *The scenario consequences shall be assessed over a period covering all possible consequences (i.e. a period of 24 hours).*