CERTIFICATION SCHEME FOR BATTERY CELLS AND PACKS FOR RECHARGEABLE ELECTRIC AND HYBRID VEHICLES

General requirements relating to certification
Application to Lithium based elements

ELLICERT | VERSION E (Including corrigendum) | OCTOBER 2012

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FOREWORD

The development of battery cells and packs for rechargeable electric and hybrid vehicles assumes that these essential components have the benefit of some form of recognition of their physical safety, whether as regards usual or unusual loads - loads that may also be called accidental or abusive - whether mechanical thermal or electrical in nature, throughout their life cycle.

This is the scope of the ELLICERT certification process and this certification scheme. This voluntary certification process covered by French Consumer Code stipulations is issued by INERIS on the basis of tests applied to cells and to packs (sets of cell modules, monitored by a dedicated control device), to which criteria are assigned so that users may have a safety guarantee for these elements.

Certification results in a certificate being issued showing compliance with this certification scheme. The certified elements bring users a set degree of safety in line with the demands set out elsewhere, e.g. by automakers.

This document complements INERIS procedure PR0861 “General rules for the product certification activity” and is intended to define the organisation implemented by INERIS for issuing battery cell and pack certification, for electrochemical energy storage for rechargeable electric and hybrid vehicles. It makes reference to this procedure.

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1. FIELD OF APPLICATION

This certification scheme applies to the certification of battery cells and packs intended for rechargeable electric and hybrid vehicles.

2. REFERENCES TO STANDARDS

The general requirements in terms of certification as targeted by this document are set out in:

- European standard EN 45011 “General requirements for bodies operating product certification systems”, in the latest applicable edition,
- French standard NF X 50-067, Development of a product or service or a product and service certification reference document,
- COFRAC document No. CPS Ref05, in the latest applicable revision, Regulations for accrediting the certification section for industrial products and services,
- COFRAC document No. CEPE Ref02, in the latest applicable revision, Criteria for accrediting certification bodies that certify products and services.

3. DEFINITIONS

Here we set out the definitions required for understanding this document:

Appeal: A request sent by the supplier of the item being evaluated for compliance, to the compliance evaluation body so that the latter body may reconsider a decision already reached in relation to this item.

Compliance certificate: The document showing compliance with this certification scheme as issued to the applicant by INERIS after the certification process.

Certification committee: The representative committee of parties affected by certification. This committee comprises three colleges: The Manufacturers’ college, the User’s college and the Administration college. It also comprises experts and representatives from the Certification Body (INERIS).

DSC: The INERIS Business Development and Certification Division

Applicant: Body (company, customer), the product certification candidate.

Complaint: A compliant may take the following definitions depending on who the target is:

The expression of a complaint, other than an appeal, as made by a person or an organisation to a compliance evaluation body and to which an answer is expected.

The expression of a complaint, as made by a person (a customer) or an organisation to a holder regarding product compliance and to which an answer is expected.

Manufacturer: An industrial company that brings the cells or packs to market. It may be a producer or distributor.

Withdrawal: Revocation, Compliance Certificate cancelation.

Surveillance: Systematic iteration of the compliance evaluation activities as the basis for maintaining the validity of the compliance affirmation.

Suspension: A temporary invalidation of compliance for all or a part of the scope of the specified certificate.

Holder: A body (company, customer) holding a valid product certification.

User: An industrial company that uses the cells and packs placed on the market by the manufacturer without any intermediate modification to these elements before their use.

4. CERTIFICATION PROCESS

4.1 SCOPE OF THE CERTIFICATION

The ELLICERT certification scheme covers voluntary certification of battery cells and packs intended for use in rechargeable electric and hybrid vehicles. It describes the organisation set up for this certification, which consists of a type examination on products prior of products prior to the first placing on the market.

This certification leads to the issuance of two types of certificate:

- One type of certificate for battery cells, and
- One type of certificate for battery packs.

Each type of certificate gives the safety class A, B or C as defined in section 7 and/or where necessary, test result levels defined in Table 4.

4.2 CERTIFICATION BODY

INERIS is an Industrial and Commercial Public Corporation (known as an Établissement Public à caractère Industriel et Commercial or EPIC in France) overseen by the Ministry in charge of the environment, and created by decree No. 90-1089 dated December 7, 1990 and published in the Official Journal of the French Republic on December 9, 1990. INERIS carries professional civil liability insurance cover for all of its activities.

Certification is one of the functions set out in the decree creating INERIS. As such, the Business Development and Certification Division (DSC) receives financial resources that are allocated to it every year for managing all certification works. These financial resources are durable ones. Budget allocations and spending are overseen by the Financial Division at INERIS, under the control of the Board of Administration.

DSC is an operational division belonging to Institut National de l'Environnement Industriel et des Risques (INERIS). Its mailing address is:

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60550 VERNEUIL EN HALATTE
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4.3 CERTIFICATION BODY RESPONSIBILITIES

Certification is granted by INERIS who is responsible for applying this certification scheme and for all decisions taken in its application. INERIS is responsible for the processing of an application.

INERIS is responsible for distributing and promoting the certification scheme and its related trademark.

INERIS is responsible for implementing mutual recognition of any certification gained on the basis of this certification scheme with other bodies.

INERIS guarantees that staff involved in certification activities in line with this certification scheme have the requisite skills and are able to maintain them.

INERIS is in charge of the secretariat and the organisation of the certification committee.

4.3.1 STAFF IN CHARGE OF CERTIFICATION

The criteria applied by INERIS for issuing its certification documents are compliant with the requirements demanded for product certification bodies:

- Staff are free of any commercial or financial pressure that could influence their assessments,
- Staffs are not designers, manufacturers, suppliers, installers or repairers of the products examined with a view to certification.

Staffs apply the INERIS code of conduct.

4.3.2 ROLE OF THE CERTIFICATION COMMITTEE

The certification committee:

- Proposes any modifications to the certification scheme that it feels are called for,
- Approves the certification scheme,
- Ensures INERIS' expertise in the fields covered by this certification scheme,
- Handles complaints from applicants who disagree with INERIS as regards the decisions reached.

The certification committee is kept informed by INERIS on:

- The number of certificates issued as part of this certification,
- Brand awareness and any recognition agreements in place with other certification bodies.

4.3.3 CERTIFICATION COMMITTEE MAKE-UP

The certification committee is a structure created by INERIS to ensure the impartiality of the certification process led by INERIS and to guarantee its proper operation. Certification committee make up complies with a balanced representation of the various parties affected by the content and operation of the certification system, and it is presided over by the INERIS Chief Certification Officer.

The make-up of the certification committee is detailed in INERIS procedure PR0864 “General Operation of Certification Committees”. Certification committee members are corporate entities designated for a renewable three-year period. Every corporate entity who is a member of the committee may, if it wishes to, also designate a deputy who is subject to the same rules as the full member.

A single physical individual may only represent one corporate entity.

4.3.4 APPROVAL - REVISION

The certification scheme is approved by the certification committee.

It may be revised after consulting the certification committee and in all cases, revision leads to approval by the committee.

4.4 REQUEST FOR, GRANTING AND WITHDRAWING CERTIFICATION

INERIS offers the applicant the ability to view product certification rules on its website. Furthermore, when it places its order, the applicant acknowledges that it is aware of the rules and commits to applying them and assuming its responsibilities.

Every request for certification made to INERIS is handled by the Certification Division of DSC which is responsible for the entire sequence of activities relating to certification, from ensuring the acceptability of the request until, when favourably concluded, handing over the certification document to the applicant.

When INERIS decides to suspend, whether for a set period of time or not, or to withdraw the use of a certification document that it has granted a company, then INERIS notifies this decision to the company that holds the certification document by recorded delivery letter. In this case, the holder company must, within fifteen calendar days from receiving the recorded delivery letter from INERIS stipulating this:

- Stop making any claims in relation to the certificate, and cease to use any documents, whether in paper or electronic format, that make reference to certification or that show up the one or more logos corresponding to certification,
- Not make any declaration such as to cause any error as regards its situation in relation to certification,

- No longer claim the benefit of the INERIS certification document and of the mark that may come with it,
- Stop using the certification mark on the product manufactured,
- And, depending on the field,
  - No longer place the product on the market as a certified product,
  - Undertake corrective actions, and where necessary, recall any faulty products.

4.5 CONFIDENTIALITY

Confidentiality of the data collected by INERIS during its certification activities is covered by the general stipulations that apply at the Institute.

Everyone involved in managing certification work (INERIS and the certification committee) are bound to professional secrecy. The files made up by the applicants along with the certification reports are confidential in nature. They are retained by INERIS with all due care.

All of the results (test reports, videos, photographs, printed strips...) further to a commercial order are “INERIS confidential” and can only be communicated to the customer itself. They can only be released to a third party with the customer’s written approval. A secrecy commitment may be provided on request.

4.6 THE ELLICERT MARK

As part of the voluntary certification activity that covers battery cells and packs, INERIS has registered the ELLICERT certification mark and its related logo:

The trademark and related logo are registered with the French International Institute for Industrial Property.

Registered on: 10 May, 2010

Under national number: 10/3737184

The rules for using certification markings are set out in procedure INERIS PR0861 “General rules for the product certification activity”.

5. SAMPLES AND TESTS

5.1 GENERAL SAFETY

So as to guarantee staffs safety, the manufacturer or the applicant must provide all of the safety data that it has on the samples that it is submitting for testing.

For the same reasons, when performing certain tests, a sufficient observation period may be applied after a test.

5.2 DEFINITIONS

- **Battery Management System (BMS):** An electronic battery pack management system including the supervision processor, the measurement electronics and the cut off device.
- **Cell:** An assembly comprising at least one positive electrode (cathode), a negative electrode (anode) and electrochemical and structural components. A cell is a standalone energy converter whose function is to provide electric power to an external circuit via a controlled internal chemical process. This energy conversion process, from chemical to electrical energy, implies an ionic exchange between electrodes subjected to a potential difference.
- **Charge:** Conversion of electric energy into chemical potential energy in a cell using the passing of current.
- **Current convention:** In this document, the current convention applied is as follows: a positive current corresponds to cell discharge and a negative current correspond to cell charge.
- **Discharge:** Spontaneous conversion of the chemical potential energy into electrical energy in a cell by the passing of current.
- **Module:** An assembly of cells that are physically and electrically linked and that can be considered to be a standalone element. A module can be considered as the smallest possible succession of block assemblies in a pack.
- **Pack:** A set of interconnected modules configured for applications using energy storage and comprising “BMS” electronics and in a modular configuration depending on the application.
- **RT (Room Temperature):** Except where otherwise stated, RT is set at 20 ± 2°C.

5.3 SAMPLES

In the following are described cell and pack samples necessary for testing. These samples shall be representative of products that will be placed on the market.

In addition to their physical definition (dimensions, weight, etc.), samples are characterised by the number of charge/discharge cycles that they have been through and by their state of charge.

If not specified differently in the testing procedures, the state of charge for cells and packs shall be set at 100% at the beginning of the tests.

For each sample, these characteristics must be as close as possible to each other, and detailed data are sent by the applicant when it sends the products to be put through the tests. The samples must have passed through every necessary manufacturing step before they are subject to testing.

For cells, the number of samples to be provided is 33. They must be numbered from 1 to 33. Information on the number of complete cycles and the state of charge of every sample must be provided by the applicant, see Table 1.

Table 1: Cell samples

Sample number	Number of complete cycles run after manufacture	State of charge*
1	Specified by the manufacturer	Specified by the manufacturer
2	Specified by the manufacturer	Specified by the manufacturer
…	…	…
33	Specified by the manufacturer	Specified by the manufacturer

* The state of charge must be such as to allow transportation operations under satisfactory conditions without sample deterioration.

For packs, as an indication, the number of samples necessary is a maximum of 5 to 10. This number may be reduced, depending on the type of packs involved.

For packs, the safety integrity level of the BMS will condition the configuration of the samples to be submitted for testing. The samples may be tested with the BMS active or inactive. Information on the number of complete cycles and the state of charge of each sample must be given by the applicant. The state of charge must be such as to allow transportation operations under satisfactory conditions without sample deterioration.

Along with the pack samples, the applicant must provide all of the necessary means and information required for properly implementing them during the tests.

Before the packs are subjected to testing, the cells that comprise them must be shown to not present excessively dangerous behaviour in the event of an internal short-circuit. This demonstration may, for example, be done by achieving a level of 5 or less (refer to subsection 5.6) in the Cell Penetration Test described in subsection 6.9.1. It must not be possible for a private individual to easily disassemble packs (using basic tools, like wrenches, screwdrivers, pliers, hammer, etc.).

When the fixture and the environment of a pack in a specific vehicle are known and described, this information can be taken into account to carry out testing (as for example by considering one or more relevant orientation(s)).

Depending on the state of charge of the samples of cells or packs supplied by the applicant, INERIS may configure the products so that they are 100% charged before every test, if necessary. The applicant commits to providing the conditions to be complied with for achieving this state of charge.

5.4 TESTS TO BE PERFORMED

The test numbering from 1 to 13 refers to subsections 6.1 to 6.13.

For cells, the tests are performed independently of each other, on three samples each time. Any given cell may not be subjected to more than one test.

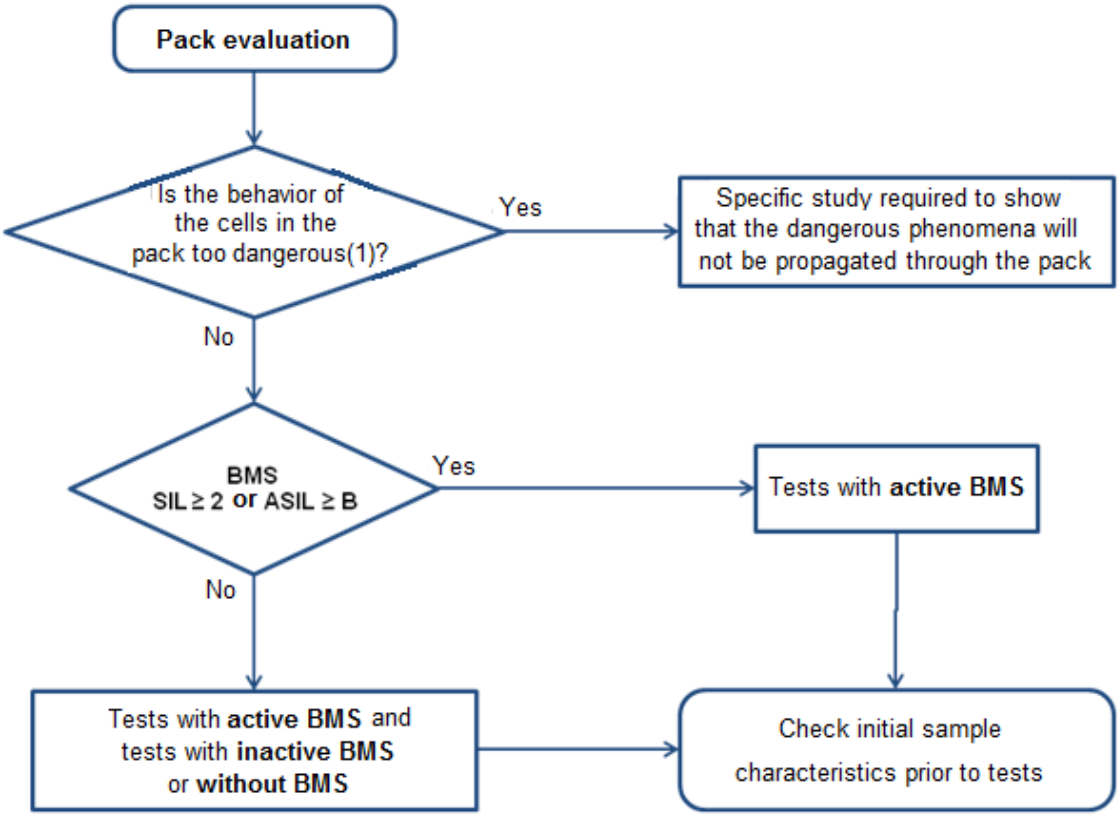
The observations and measurements to be done after each test to determine its results are defined in Table 3 in subsection 5.5.

For packs, a preliminary evaluation (see Figure 1) is required, especially to check the presence of a minimum number of prerequisites and to determine according to the safety integrity level of the pack's BMS (see Annex section 8) and to determine in what configuration(s) the pack will be tested.

Once this first step is complete, the tests are then performed separately, on a sample of the one or more configurations retained for the tests. The same pack may be subjected to a number of tests so long as its condition after each test allows this. If this is not possible, a new sample is used.

The observations and measurements to be performed after every test to determine its results are set out in Table 3 in subsection 5.5.

Figure 1: Preliminary pack evaluation prior to testing



(1) See Table 3 and subsections 6.4 and 6.9 hereinafter

Test results gained according to requirement of standards or regulations mentioned in Table 2 can be taken into account by the certification body when the conditions to obtain them are seen satisfactory.

Table 2 : Equivalency testing with ELLICERT

		Cell	Pack
1	**Vibration**	UN Manual Section 38.3 Test method T3 (1)	R100 annex 8A (4)
2	**Thermal cycle**	UN Manual Section 38.3 Test method T2 (1)	R100 annex 8A (4) or ISO 12405-2 §8.2 (5)
3	**Low pressure**	UN Manual Section 38.3 Test method T1 (1)	UN Manual Section 38.3 Test method T1 (1)
4	**Thermal stability**	SAE J2464 §4.4.2 (2)	Not required
5	**Forced charge**	IEC 62660-2 §6.3.2 (3)	ISO 12405-2 §9.3 (5)
6	**Forced discharge**	IEC 62660-2 §6.3.3 (3)	ISO 12405-2 §9.4 (5)
7	**Impact or jolt**	IEC 62660-2 §6.1.2 (3)	R100 annex 8C (4)
8	**Crush**	IEC 62660-2 §6.1.3 (3)	R100 annex 8D (4)
9	**Penetration**	SAE J2464 §4.3.3 (2)	Not required
10	**External short-circuit**	IEC 62660-2 §6.3.1 (3)	R100 annex 8F (4) with a resistance of 100mΩ
11	**Fall**	Non equivalency	SAE J2464 §4.3.2 (2)
12	**Immersion**	Not required	SAE J2464 §4.3.5 (2)
13	**Real or simulated outside fire**	Not required	R100 annex 8E (4)

(1) UN Recommendations on the Transport of Dangerous Goods - Manual of Tests and Criteria ref. ST/SG/AC.10/11/Rev.5 (2009)
(2) SAE J2464 Nov 2009 “EV and HEV Rechargeable Energy Storage System (RESS) Safety and Abuse Testing”
(3) IEC 62660-2:2010 “Secondary lithium-ion cells for the propulsion of electric road vehicles – Part 2: Reliability and abuse testing”
(4) UNECE Regulation N°100
(5) ISO 12405-2:2012 “Electrically propelled road vehicles -- Test specification for lithium-ion traction battery packs and systems -- Part 2: High-energy applications”

5.5 DIAGNOSTICS

In addition to observing the various events that occur during the tests, after each test diagnostics are generated on the condition of the tested sample, comparing it with its initial condition (before testing). For this purpose, Table 3 below summarises the various parameters and values that may be compared. Some of these values may also be monitored continuously during the tests.

Table 3: Measured data

	Visual inspection (deformation, stress, cracking, etc.)	Voltage	Current	Resistance	Isolation measurement	State of charge	Weight loss	Outside temperature	Gas analysis*
Test 1	**C**	**C**					**C/P**	**C**	
Test 2	**C/P**	**C/P**			**P**	**C/P**	**C/P**	**C/P**	
Test 3	**C/P**	**C/P**				**C/P**	**C/P**		
Test 4	**C**	**C**						**C**	**C**
Test 5	**C/P**	**C/P**	**C/P**		**P**	**C/P**		**C/P**	
Test 6	**C/P**	**C/P**	**C/P**		**P**	**C/P**		**C/P**	
Test 7	**C/P**	**C/P**			**P**	**C/P**		**C/P**	
Test 8	**C/P**	**C/P**			**P**	**C/P**	**C/P**	**C/P**	**C/P**
Test 9	**C**	**C**					**C**	**C**	**C**
Test 10	**C/P**	**C/P**	**C/P**	**C**	**P**			**C/P**	**C/P**
Test 11	**C/P**	**C/P**			**P**	**C/P**		**C/P**	
Test 12	**P**	**P**			**P**			**P**	
Test 13	**P**						**P**		**P**

* Insomuch as gas is released and an analysis is possible
C: Relates to cells
P: Relates to packs

5.6 RESULT ENCODING

All of the data collected this way are used to produce a test result which is expressed in levels 0 to 7 as defined in Table 4.

Table 4: Test result levels based on effects observed

Level	Description	Classification criteria
0	No effect	No effect, no loss of function.
1	Passive protection enabled	No danger, no damage, reversible function loss. Replacing or refurbishing the protection mechanism is enough to return to normal operation.
2	Defects, irreversible damage	No danger, but damage and an irreversible function loss. Replacement or repairs are required. (IP20 maintained)
3	Minor leak / Gas release	Slight leaks, without fire or flame or explosion. Weight loss < 50% of electrolyte weight*. (IP20 maintained)
4	Major leak / Gas release	Major leaks, without fire or flame or explosion. Weight loss ≥ 50% of electrolyte weight*. (IP20 maintained)
5	Bursting	Bursting without violent projections or explosion.
6	Fire presence	Continuing inflammation and combustion.
7	Explosion	Complete object breakdown, violent projections.

* Electrolyte = solvent + solute

In the table the wording “IP20 maintained” make reference to the IP code which defines the degree of protection according to EN 60529 (IEC 529) standard.

6. TEST DESCRIPTIONS

The following subsections described the general conditions for each test as well as the specificities to apply where necessary for cells and packs.

The practical details for testing may be, if necessary for example regarding the particularities of samples, adapted by INERIS on a case by case and on its responsibility pursuant subsection 4.3.

Test methods are sorted in 3 types:

Type 1: allows a ranking in damages after a fixed time

Type 2: allows a ranking in time with fixed damages at t_1, t_2, t_3...

Type 3: allows a ranking in stimuli, event expected for different level of stimuli

6.1 TEST 1: VIBRATION

6.1.1 CELL (TEST TYPE 1)

The cells are solidly fixed onto the vibrator plate without suffering any deformation so that the vibration is transmitted in full. The test is carried out at a temperature of 20 ± 10°C.

A sine wave is applied to them with a logarithmic frequency scroll from 7 Hz to 200 Hz then back to 7 Hz in 15 minutes.

This cycle is repeated 12 times during three hours in all for each of the three cell mounting positions that are perpendicular to each other. One of the vibration axes must be perpendicular to the side that bears the terminals.

The logarithmic frequency scroll is performed as follows: from 7 Hz maximum acceleration of 1 g_n is maintained until the 18 Hz frequency is reached. Then the amplitude is maintained at 0.8 mm (total travel: 1.6 mm) and the frequency is increased until a maximum acceleration level of 8 g_n is reached (around 50 Hz). Maximum acceleration of 8 g_n is then maintained until the frequency reaches 200 Hz.

6.1.2 PACK (TEST TYPE 1)

The packs are solidly fixed onto the vibrator plate without suffering any deformation so that the vibration is transmitted in full. The test is carried out at a temperature of 20 ± 10°C.

The packs to be tested are in a state of charge between 50% et 100% and in normal operation condition. A sine wave is applied to them with a logarithmic frequency scroll from 7 Hz to 50 Hz then back to 7 Hz in 15 minutes.

Frequency (Hz)	Acceleration (m/s^2)
7 - 18	10
18 – 30	Progressively decreased from 10 to 2
30 - 50	2

This cycle is repeated 12 times during three hours in all for each of the three pack mounting positions that are perpendicular to each other. Recording and monitoring of parameters on the packs tested is continued for 1 hour after the end of the test.

6.2 TEST 2: THERMAL CYCLE

6.2.1 CELL (TEST TYPE 1)

The cells to be tested must be stored for at least six hours at a temperature of 75 ± 2°C, then for at least six hours at a temperature of -40 ± 2°C. No more than 30 minutes must elapse to transfer between one extreme temperature to the other. The procedure is repeated 10 times then all of the tested cells are stored for 24 hours at ambient temperature.

6.2.2 PACK (TEST TYPE 1)

The packs to be tested are in a stage of charge of 50%.

The packs are stored for at least 1 hour at a temperature of 85 ± 2°C, then for at least 1 hour at a temperature of -40 ± 2°C. No more than 30 minutes must elapse to transfer between one extreme temperature to the other. The procedure is repeated 5 times then all of the tested packs are stored for 24 hours at ambient temperature.

Recording and monitoring of parameters on the packs tested is continued for 1 hour after the end of the test.

6.3 TEST 3: LOW PRESSURE

6.3.1 CELL (TEST TYPE 1)

The cells to be tested are stored for at least six hours at a pressure of 11.6 kPa or less, at ambient temperature.

6.3.2 PACK (TEST TYPE 1)

The packs to be tested are stored for at least six hours at a pressure of 11.6 kPa or less, at ambient temperature.

6.4 TEST 4: THERMAL STABILITY

6.4.1 CELL (TEST TYPE 3)

The cells to be tested are placed in a chamber able to heat them up to 150°C.

The chamber temperature is increased in 5°C increments (minimum ramp-up 5°C/min). The temperature is held at this level for 30 minutes or until any self-heating is detected.

If self-heating is detected (> 1.0°C per minute) then hold the chamber temperature until the sample temperature stabilises or until the temperature exceeds 150°C or until a dangerous event appears (leak, bursting, explosion, etc.). The lowest temperature at which self-heating is detected and evolved towards a dangerous event is the one recorded.

6.4.2 PACK

Reserved

6.5 TEST 5: FORCED CHARGE

6.5.1 CELL (TEST TYPE 3)

Prior charging, the cells must be discharged at room temperature with a constant current equal to C/3 up to the final tension specified by the manufacturer.

Then, the cells must be charged according to the method specified by the manufacturer, at 100% at room temperature. Continue to charge the cells over 100% by a charging current of 1C at room temperature with power source able to maintain a constant charge current. These forced charge conditions should be maintained until one of the following conditions appears:

- The tension of cells reach two time the maximal tension specified by the manufacturer,
- State of charge reach 200%,

6.5.2 PACK (TEST TYPE 1)

The packs are at room temperature, charged at 100% and in normal operating conditions. The charge active control system must be disabled.

The packs are charged by applying a constant current equal to 2C and with a voltage level that does not exceed 120% of their maximum voltage. Forced charge conditions shall be maintained until one of the following conditions appears:

- Charging is interrupted by a pack built-in passive safety device,
- State of charge exceeds 130%,
- The temperature of the packs rises by more than 55°C over their initial temperature.

The recording of measured parameters should continue for one hour after the end of the test.

6.6 TEST 6: FORCED DISCHARGE

6.6.1 CELL (TEST TYPE 3)

Discharge the cells to a state of charge of 0% and continue discharging during 90 minutes at a constant current of 1C.

6.6.2 PACK (TEST TYPE 1)

The packs are at room temperature and in normal operating conditions. The discharge active control system must be disabled.

The packs are discharged with a constant current equal to C/3. Forced discharge conditions shall be maintained until one of the following conditions appears:

- Discharging is interrupted by a pack built-in passive safety device,
- The pack's voltage value is below 25% of its rated voltage.

The recording of measured parameters should continue for one hour after the end of the test.

6.7 TEST 7: SHOCK OR JOLT

6.7.1 CELL (TEST TYPE 1)

The cells are mounted onto the impact test device using a rigid mount that holds all of the mounting surfaces for each cell. Each cell is subject to a semi-sine wave pulse with a peak acceleration of 150 g_n for 6 ms. Each cell is subject to three pulses in the positive direction followed by three pulses in the negative direction in each of the three cell mounting positions that are perpendicular to each other, i.e. a total of 18 pulses.

6.7.2 PACK (TEST TYPE 1)

Pack under test is in normal operating conditions at room temperature and in a state of charge of 50%.

Pack under test is submitted to acceleration according to the corridor showed in Figure 2 with the specifications given in Table 5.

Figure 2

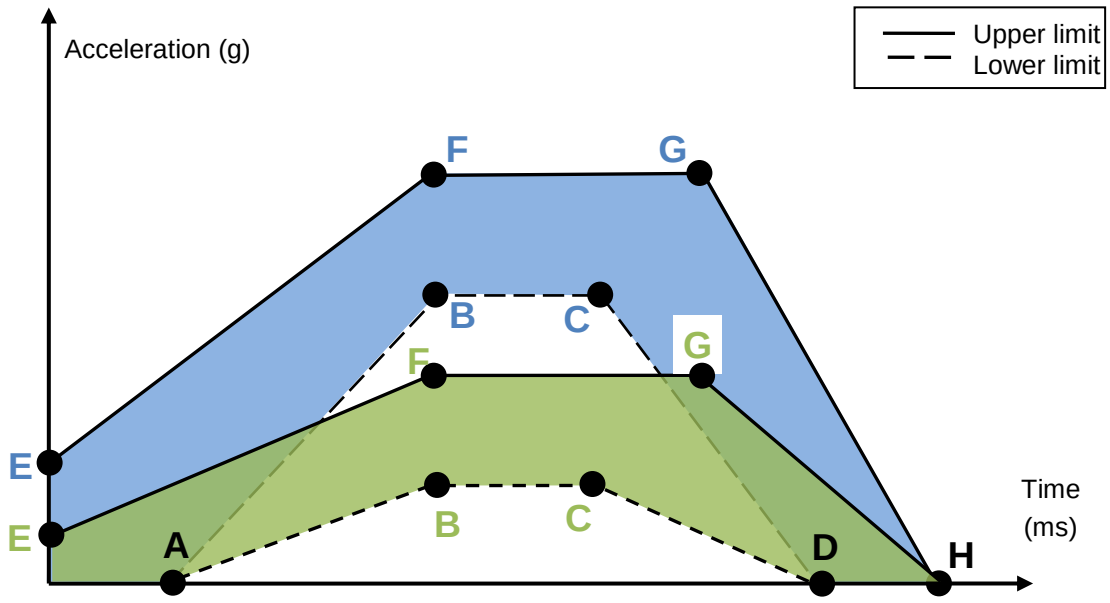


Table 5

Point	Time (ms)	Acceleration (g)	
		Longitudinal	Transverse
A	20	0	0
B	50	20	8
C	65	20	8
D	100	0	0
E	0	10	4,5
F	50	28	15
G	80	28	15
H	120	0	0

The recording of measured parameters should continue for one hour after the end of the test.

6.8 TEST 8: CRUSH

6.8.1 CELL (TEST TYPE 3)

Cells are placed on flat surface electrically insulated and shall be crushed with a cylindrical or semi-cylindrical tool or a spherical or hemispheric tool of 150 mm diameter. Cylindrical shaped tool is recommended for cylindrical cells and spherical shaped tool for prismatic cells. The crushing force shall be applied so quasistatic in a direction substantially perpendicular to an inner active face of the positive and negative electrodes.

Step 1: the force is applied progressively until one of the following conditions appears:

a) Sudden decrease of voltage of more than one third of the initial cell's voltage,

b) Result of a level greater than or equal to 5 (see Table 4),

c) Obtainment of a 15% distortion relative to the initial size of the cell.

If a) or b) conditions are not reached, the crush force is maintained either during a 2 hours observation period or until the cell's temperature decreased by 20% from the maximum reached temperature, whichever happen first.

The recording of measured parameters should continue during the whole observation period.

Step 2: If a) or b) conditions did not appear during the observation period of step 1, the application of force is continued until the occurrence of one of the conditions following:

a) Sudden decrease of voltage of more than one third of the initial cell's voltage,
b) Result of a level greater than or equal to 5 (see Table 4),
c) Obtainment of a 30% distortion relative to the initial size of the cell.

If a) or b) conditions are not reached, the crush force is maintained either during a 2-hour observation period or until the cell's temperature decreased by 20% from the maximum reached temperature, whichever happen first.

The recording of measured parameters should continue during the whole observation period.

Step 3: If a) or b) conditions did not appear during the observation period of step 2, the application of force is continued until the occurrence of one of the conditions following:

a) Sudden decrease of voltage of more than one third of the initial cell's voltage,
b) Result of a level greater than or equal to 5 (see Table 4),
c) Obtainment of a 50% distortion relative to the initial size of the cell,
d) The force is 1000 times the weight of the cell.

If a) or b) conditions are not reached, the crush force is maintained either during a 2-hour observation period or until the cell's temperature decreased by 20% from the maximum reached temperature, whichever happen first.

The recording of measured parameters should continue during the whole observation period.

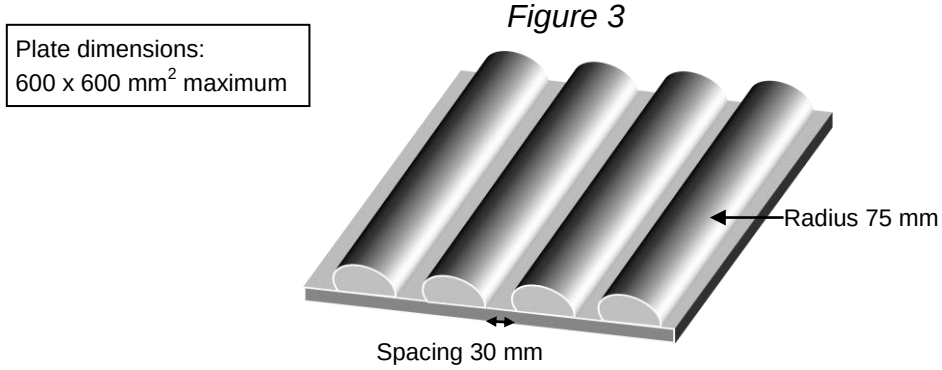
6.8.2 PACK (TEST TYPE 1)

Pack under test is in normal operating conditions at room temperature and in a state of charge of 50% or higher.

The pack is placed on a flat surface and electrically insulated and shall be crushed with a plate similar to that shown in Figure 3, the force applied is at least 100 kN, but not exceeding 105 kN. The force shall be applied in less than 3 minutes and maintained for at least 100 ms, not to exceed 10 seconds.

If the implementation of the pack in the vehicle is known, the force to be applied is perpendicular to the direction of movement of the vehicle and the side faces of the pack. If the implementation of the pack in the vehicle is not known, the force is applied to compress the greater length of the pack.

Figure 3



The recording of measured parameters should continue during the whole observation period.

6.9 TEST 9: PENETRATION

6.9.1 CELL (TEST TYPE 1)

The cell is placed on an electrically isolated plate. The cell is pierced right through using a pointed cylindrical rod made from mild steel and with a diameter of 3 mm and with a penetration rate of 8 cm/s. The tip of the rod is fitted with a cone that has a height equal to the diameter of the rod.

Penetration takes place through the cell, perpendicularly to the electrodes. After piercing, the rod is held in place for at least one hour.

6.9.2 PACK

Reserved

6.10 TEST 10: EXTERNAL SHORT-CIRCUIT

6.10.1 CELL (TEST TYPE 1)

The cells to be tested are conditioned in oven at a temperature of 55 ± 2°C.

Then, they are submitted to short-circuit conditions with an external resistance of no more than 5 mΩ at the temperature of 55 ± 2°C. The short-circuit is maintained during at least 1 hour after the outer case of the cell was 55 ± 2°C again.

6.10.2 PACK (TEST TYPE 1)

The pack terminals are placed in an external short-circuit condition with a resistance of no more than 100 mΩ and this for ten minutes. The pack's behaviour is observed for at least two hours after the end of the test.

6.11 TEST 11: FALL

6.11.1 CELL (TEST TYPE 1)

The cell is released from a height of 1.50 m over a hard non conductive, non elastic surface that is flat and horizontal. The test is repeated twice for each of the cell's three main perpendicular axes.

6.11.2 PACK (TEST TYPE 1)

The pack is released from a height of 2 m (taken from the lowest point) over a hard non conductive, non elastic surface that is flat and horizontal.

The fall is made in such a way that a corner of the packs reaches the ground first.

6.12 TEST 12: IMMERSION

6.12.1 CELL

Reserved

6.12.2 PACK (TEST TYPE 1)

The pack is fully immersed in salt water (with a salinity of approx. 35 g/l) at ambient temperature. Immersion is maintained for two hours unless any notable and visible change to the sample takes place thereby ending the test.

Note: Packs which are rated IP67 do not need to undergo this test and are considered to fulfil class A requirement for this test. The wording "IP67" make reference to the IP code which defines the degree of protection according to EN 60529 (IEC 529) standard.

6.13 TEST 13: REAL OR SIMULATED OUTSIDE FIRE

6.13.1 CELL

Reserved

6.13.2 PACK (TEST TYPE 3)

The package is placed on a grid of steel bars of diameter between 6 and 10 mm spaced 40 to 60 mm. The grid is placed 50 cm above a tray containing heptanes (or liquid fuel equivalent) 60 seconds prior ignited. Direct exposure to flame is maintained for a period of 70 seconds. Then a screen of perforated bricks is placed between the flame and the pack. Indirect exposure to flame is maintained for 530 seconds. The tray is then removed and the observation of the effects continued for 10 minutes or until an event requiring discontinuation of observation.

Alternatively to the test described above, radiant heat can be used to simulate a fire flame outside the pack, making it easier for the simulation data collection and gas sampling.

The thermal environment outside of the pack shall be brought to room temperature to 890°C in less than 180 seconds, and the pack must remain exposed to this temperature for 10 minutes or until an event requires the cessation of testing. For this, the pack can be placed in a chamber whose internal temperature is at least 890°C.

7. ACCEPTABILITY LEVELS AND SAFETY CLASSES

The results obtained in the tests refer to levels (see Table 4). These define the safety class for cells and packs. Three safety classes are defined in Tables 6 and 7 for certifying cells and packs. The classes are designated by letters A, B and C. Their definition is based on the test result levels as defined in Tables 6 and 7. Class C corresponds to the minimum safety levels that can be demanded of cells and packs while classes B and A correspond to more severe safety demands.

Table 6: Safety classes for Cells

		Class A	Class B	Class C
1	Vibration	Level 0	Level 1	Level 2
2	Thermal cycle	Level 0	Level 1	Level 2
3	Low pressure	Level 0	Level 1	Level 2
4	Thermal stability	See Matrix A	See Matrix A	See Matrix A
5	Forced charge	Level 2 at 200%	Level 2 at 130%	Level 3 at 130%
6	Forced discharge	Level 2 at -100%	Level 2 at -30%	Level 3 at -30%
7	Impact or jolt	Level 0	Level 1	Level 2
8	Crush	Level ≤5 at 50%	Level ≤5 at 30%	Level ≤5 at 15%
9	Penetration	Level 3	Level 4	Level 5
10	External short-circuit	Level 2	Level 3	Level 4
11	Fall	Level 0	Level 2	Level 3
12	Immersion	Test not required	Test not required	Test not required
13	Real or simulated outside fire	Test not required	Test not required	Test not required

Matrix A

Level / Test temperature	3	4	5
T ≤ 80°C	C	C	C
80°C < T ≤ 120°C	B	B	C
120°C < T	A	B	C

Table 7: Safety classes for Packs

		Class A	Class B	Class C
1	Vibration	Level 0	Level 1	Level 2
2	Thermal cycle	Level 0	Level 1	Level 2
3	Low pressure	Level 0	Level 1	Level 2
4	Thermal stability	Test not required	Test not required	Test not required
5	Forced charge	Level 1 à 130%	Level 2 à 130%	Level 3 à 130%
6	Forced discharge	Level 1 à -30%	Level 2 à -30%	Level 3 à -30%
7	Impact or jolt	Level 2	Level 3	Level 4
8	Crush	Level 3	Level 4	Level 5
9	Penetration	Test not required	Test not required	Test not required
10	External short-circuit	Level1	Level 2	Level 4
11	Fall	Level 0	Level 2	Level 3
12	Immersion	Level 2	Level 3	Level 4
13	Real or simulated outside fire	Level 5 at 10 min	Level 5 at 5 min	Level 5 at 2 min or Level 6 at 10 min

8. ANNEXES

Annex 1

Recognition of Functional Safety Aspects

Any recognition for BMS functional safety is based on an evaluation of instrumented safety systems in line with the functional safety standard IEC 61508 and/or standard ISO 26262 that is specific to road vehicles.

Evaluations must be conducted by bodies that are independent of the designers and manufacturers and must be formally expressed by issuing a certificate showing compliance with functional safety standards specifying the degree of safety achieved (SIL and/or ASIL) for every BMS safety function. When the BMS' degree of functional safety is dependent on specific conditions of use, the certificate must detail these conditions and the related limits.

The independence between the designer and the evaluator of ASIL levels must comply with the requirements of ISO 26262-2 (see in particular paragraph 6.4.6 of this standard).

An evaluation of the equipment comprises an evaluation of the hardware and software equipment linked to this equipment.

An evaluation of the quality of the development process must also be made and must be formally expressed by issuing an audit report or a conformity certificate for the company's development process in relation to functional safety standards.

The sector based standards taken into account in the ELLICERT certification scheme must comprise a correspondence table with the SIL levels in standard IEC 61508. For standard ISO 26262, instrumented systems must have an ASIL level in excess of A.

Annex 2
Test Conditions

Current measurement

The devices used to measure current must be ammeters with a precision class of 0.5 or higher. The complete ammeter, jumper and wire set must be in a precision class of 0.5 or higher.

Voltage measurement

The devices used to measure voltage must be voltmeters with a precision class of 0.5 or higher. The resistance of the voltmeters used must be at least 1000 Ω/V.

Temperature measurement

The element temperature must be measured using a surface temperature measurement device. The temperature should be measured in a location that reflects the temperature of the electrolyte as best possible. The temperature measurement device must have a suitable temperature range where the value of each graduated division does not exceed 1°C. The device's absolute precision must be at least 1°C.

The temperature measurement point must be the one specified by the manufacturer, as being a location that reflects the temperature of the electrolyte as best possible. If no point is specified, the point should be at the centre of the longest side of an element, whether a unique element or one that is an integral part of a one piece unit.

Test time measurement

The devices used for time measurements must have a precision of ±1% or higher.

Data recordings

Data recordings should include the time, temperature, voltage, current and all visual observations such as physical deformations or faults. Videos and photographs taken before, during and after the test should also be recorded.

Measurement precision

The various instruments and values measured must be compliant with a precision of ± 1% for electrical data such as voltage, current, capacity, ± 2°C for thermal data like the temperature and ± 0.1% for mechanical data such as the weight, dimensions, volume.

An inaccuracy calculation must be performed for all measurement systems.

Annex 3

Certification Committee Operation

The ELLICERT Certification Committee is a structure created by INERIS with a makeup that ensures a balanced representation of the various parties affected by the test certification scheme. It is statutorily presided by the Chief Certification Officer at INERIS who names a Secretary from the INERIS permanent team and who is a part of the Certification Division.

Certification Committee Makeup

The Certification Committee comprises members who belong to the following five colleges:

- Manufacturers' college
- User's college
- Administration college
- Expert's college
- Certificator's college

The members sign a commitment binding them to confidentiality, impartiality and independence and they are free of all commercial and financial pressures likely to influence the decisions reached by the committee. They act within the Committee on behalf of the college they belong to.

Voting and Decision Making

Every college counts for one vote, regardless of the number of representatives it comprises, i.e. a total of five votes at most. Decisions are taken by the Certification Committee using majority voting.

When it is not possible to gather the Committee and certification scheme documents must be approved so as to ensure continuing certification activity, a postal ballot of all Committee members is possible with a one week lead-time once the document covered by the vote has been presented or transmitted. The same voting rules apply.

Meeting Frequency

Meeting frequency is determined as required by the Certification Committee. Nevertheless, the Committee will physically meet at least once a year when called to by INERIS.

Presence of Outside Persons

The Certification Committee may request the presence of persons from outside of the Certification Committee to gain additional views on a point.

In this case, the Committee does not deliberate nor will it reach any decision in the presence of this person who must leave the meeting as soon as their contribution has been made.