Proposal how to structure the RESS safety requirements

Status: 17.01.2011

Blue = German VDA, German TÜV´s, Battery Manufacturer
Red = TÜV Süd
Green = Mercedes
Brown = SP Technical Research Institute of Sweden
Purple = JAPAN (JASIC)
UN Test = UN 38.3 Requirements
Green = Amendments during the 2nd meeting in Paris

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1. SCOPE

The following prescriptions apply to safety requirements with respect to the Rechargeable Energy Storage Systems (RESS) of road vehicles of categories M and N, equipped with one or more traction motor(s) operated by electric power and not permanently connected to the grid.

2. DEFINITIONS

(Comment)

Introduction: In order to facilitate the discussion in the RESS informal sub-group, it is important to establish common understanding of key terminologies. Therefore, the definition of terminologies that may be used for the sub-group discussion should be reviewed at early stage of discussion and then keep updated throughout the development of the Regulation.

2.1. Basic terms.

Definitions

2.1.1 "Rechargeable energy storage system (RESS)" means the rechargeable energy storage system that provides electric energy for electric propulsion.[The RESS includes a completely functional energy storage system consisting of the pack(s) and necessary ancillary subsystems for physical support, thermal management, electronic control and enclosures.] (=> R100)

~~**"Rechargeable energy storage system (RESS)"**~~
~~means rechargeable energy storage systems which provide electric energy for electrical propulsion~~

~~**"Battery System"???**~~

2.1.2 "Cell" means a single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals. (=> out of UN 38.3)

2.1.3 "Lithium ion cell" means a rechargeable electrochemical cell whose electrical energy is derived from the insertion/extraction reactions of lithium ions between the anode and the cathode. (=> out of IEC 62660)

2.1.4 "Battery" means two or more cells which are electrically connected together fitted with devices necessary for use, for example, case, terminals, marking and protective devices. (=> out of UN 38.3)

2.1.5 "Battery enclosure" means the physical housing surrounding RESS ~~battery system~~ components, particularly cells or [cell assemblies]. (=> based on SAE J2929)

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2.2. Terminologies may be used for pass/fail criteria

Definitions

2.2.1 "Explosion" means very fast release of energy sufficient to cause pressure waves and/or projectiles that may cause considerable structural and/or bodily damage. (=> out of SAE J2929)

2.2.2 "Fire" means the emission of flames from a battery enclosure that may spread to the other part of the vehicle.. Sparks are not flames. (=> out of SAE J2929)

2.2.3 "Cell rupture" means the mechanical failure of a cell container induced by an internal or external cause, resulting in exposure or spillage but not ejection of solid materials. (=> out of UN 38.3)

[2.2.4 "Battery enclosure rupture" means openings through the battery enclosure which are created or enlarged by an event and which are sufficiently large for a 50 mm diameter sphere to contact battery system internal components (see ISO20653, IPXXA). (=> out of SAE J2929)]

"Module" ???

"**Working voltage**"
means the highest value of an electrical circuit voltage root mean square (rms), specified by the manufacturer or determined by measurement, which may occur between any conductive parts in open circuit conditions or under normal operating condition. If the electrical circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively. (=> out of R100)

"High Voltage" means the classification of an electric component or circuit, if its working voltage is > 60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (rms). (=> out of ECE R100)

Nominal voltage is the voltage given by the supplier as the recommended operating voltage of their battery system

undefined venting ???

3. TECHNICAL REQUIREMENTS
A) Priority Requirements

REMARK: AS SUGGESTED BY THE SEPARATE DOCUMENT BY JASIC, THE PRIORITY OF THE REQUIREMENT SHOULD BE DEFINED AT FIRST AND THE DISCUSSION SHOULD BE PRECEDED ACCORDING TO THE PRIORITY.

3.1 Vibration
3.1.1 Rationale
Simulates a vibration environment which a battery system will likely experience during the lifetime of the vehicle. Vibration of the vehicle-body is random vibration induced by rough-road-driving as well as internal vibration of the power train.
This test checks the RESS for specific malfunctions and breakage caused by this vibration.

3.1.2 Requirement
REMARK: Currently Lithium ion batteries must comply with UN 38.3 which has been contributed to ensure the safety performance of such batteries. Accordingly, this requirement is not considered as a priority issue.

3.1.2.1 Conditions
REMARK: If type approval requirement is considered as necessary, it should be based on UN38.3 procedure to avoid duplicated certification testing. Test on large battery pack may have difficulty in mounting on the test rig where failures tend to happen around the mounting area.
~~[ISO 12405 Part 1]~~
Remark:
ISO 12405 Part 1is a possible suggestion but one should check that these conditions cover conditions in other requirements so that two tests are not necessary.

The following test can be conducted with the RESS or with module(s) of the RESS.

[If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.]

Due to the big mass of this RESS the maximum test frequency is limited to 200 Hz, but the vibration test shall be performed in sequence in all three spatial directions.

Adjust the State of Charge (SOC) with discharge to [50 %] before starting the vibration test profile.

The test shall be performed according
- to [IEC 60068-2-64], see Tables 1 to 4 or
- to a test profile determined by the vehicle-manufacturer, verified to the vehicle application and agreed by the Technical Service.

The RESS shall be mounted on a shaker test bench in a way that the load application is equivalent to the mounting in the vehicle.

The module(s) shall be mounted on a shaker test bench in a way that the load application is equivalent to each mounting position (tolerance to be defined) in the RESS.

With only one test device the vibration test shall be performed in a sequence of all three spatial directions

- vertical direction (Z),
- transverse direction (Y) and
- longitudinal direction (X).

a) [The mechanical stresses acting on the RESS are specified by a stochastic acceleration - time function with test duration per spatial direction of 21 h. The test duration per spatial direction can be reduced to 15 h if the test procedure is performed with two identical RESS, or to 12 h if the test procedure is performed with three identical RESS, respectively.]

b) [The test duration per spatial direction is 12 h.]

For longitudinal direction (X) see table1, for transverse direction (Y) see table 2 or 3 and vertical direction (Z) see table 4.

[If the RESS is designed for a vehicle mounting position below the vehicle passenger compartment, then the reduced spectrum PSD_horizontal transverse_YPassenger_compartment_bottom according to Table 3 shall be used.]

Table 1 — Values for PSD_horizontal_longitudinal_X

Frequency [Hz]	PSD [g²/Hz]	PSD [(m/s²)²/Hz]
5	0,0125	1,20
10	0,03	2,89
20	0,03	2,89
200	0,00025	0,02
RMS	0,96 g	9,42 m/s²

Table 2 — Values for PSD_horizontal_transvers_Y

Frequency [Hz]	PSD [g²/Hz]	PSD [(m/s²)²/Hz]
5	0,04	3,85
20	0,04	3,85
200	0,0008	0,08
RMS	1,23 g	12,07 m/s²

Table 3 — Values for PSD_horizontal_transvers_Y Passenger_compartment_bottom

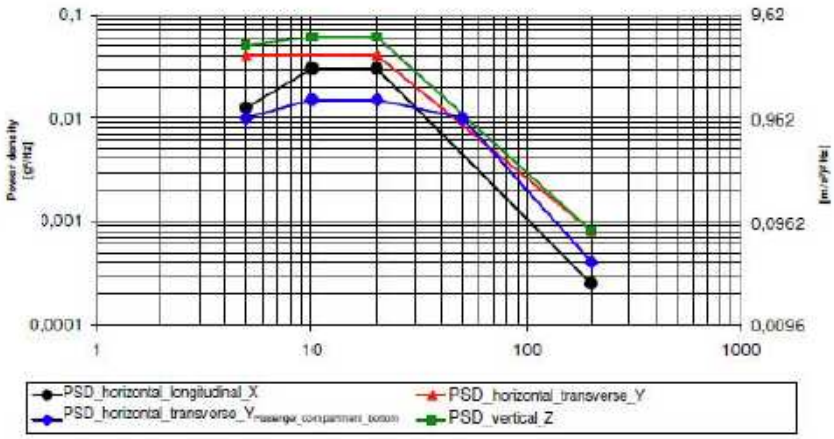
Frequency [Hz]	PSD [g²/Hz]	PSD [(m/s²)²/Hz]
5	0,01	0,96
10	0,015	1,44
20	0,015	1,44
50	0,01	0,96
200	0,0004	0,04
RMS	0,95 g	9,32 m/s²

Table 4 — Values for PSD_vertical_Z

Frequency [Hz]	PSD [g²/Hz]	PSD [(m/s²)²/Hz]
5	0,05	4,81
10	0,06	5,77
20	0,06	5,77
200	0,0008	0,08
RMS	1,44 g	14,13 m/s²

Figure 5 shows the interpolation between the data-points of tables 1 to 4.

Figure 5 — PSD spectra for sprung masses (masses mounted on vehicle body)



The following control parameters shall be ensured:
− Delta frequency 1,25 ± 0,25 Hz
[− Inner range of tolerance ± 3 dB (warning level)
− Outer range of tolerance ± 6 dB (shut-down level)]

At the end of the vibration test the isolation resistance has to be measured.

UN Test procedure
(i) ten cells at first cycle, in fully charged states;

(ii) four small batteries at first cycle, in fully charged states;

(iii) four small batteries after 50 cycles ending in fully charged states;
(iv) two large batteries at first cycle, in fully charged states; and
(v) two large batteries after 25 cycles ending in fully charged states.

Cells and batteries are firmly secured to the platform of the vibration machine without distorting the cells in such a manner as to faithfully transmit the vibration. The vibration shall be a sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes.
This cycle shall be repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the cell. One of the directions of vibration must be perpendicular to the terminal face.
The logarithmic frequency sweep is as follows: from 7 Hz a peak acceleration of 1 gn is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8 gn occurs (approximately 50 Hz). A peak acceleration of 8 gn is then maintained until the frequency is increased to 200 Hz.

3.1.2.2 Acceptance criteria based on [RESS]

During the test, including [1] h after the test ~~the defined recovery period~~, the battery system shall exhibit no evidence of

a) undefined venting or
b) battery enclosure rupture ~~(no degradation of protection degree)~~ or
c) fire or
d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test ~~and~~ shall maintain high voltage to ground isolation no less than 100 Ω/Volt ~~specified for the RESS type under inspection.~~

UN Requirement
Cells and batteries meet this requirement if there is

- no mass loss,
- no leakage,
- no venting,
- no disassembly,
- no rupture and
- no fire and
- if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure.

The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

3.1.2.3 Acceptance criteria based on [modules]

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or

d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test shall maintain no degradation of high voltage to ground isolation as defined by the battery-manufacturer.

3.1.3 Verification

~~Test according to [ISO 12405 part 1] /Documentation / Calculation / Simulation~~

a) to d) of 3.1.2.2 shall be checked by visible inspection.

The isolation resistance shall be measured according to Annex 1.

3.2 Thermal Shock and Cycling

3.2.1 Rationale

Thermal shock cycling is performed to determine the resistance of the RESS to sudden changes in temperature. The RESS undergo a specified number of temperature cycles, which start at RT followed by high and low temperature cycling. It simulates a rapid environmental temperature change which a battery system will likely experience during its life.

3.2.2 Requirement

REMARK: Currently Lithium ion batteries must comply with UN 38.3 which has been contributed to ensure the safety performance of such batteries. Accordingly, this requirement is not considered as a priority issue.

3.2.2.1 Conditions

REMARK: If type approval requirement is considered as necessary, it should be based on UN38.3 procedure to avoid duplicated certification testing.

Test according to the following procedure and the profile shown in figure 1. Fully charged cells or RESS are subjected to temperature cycling (–20 ℃, +75 ℃), in forced draught chambers, according to the following procedure.
Step 1: Place the cells or RESS in an ambient temperature of 75 ℃ ± 2 ℃ for 4 h.
Step 2: Change the ambient temperature to 20 ℃ ± 5 ℃ within 30 min and maintain at this temperature for a minimum of 2 h.
Step 3: Change the ambient temperature to –20 ℃ ± 2 ℃ within 30 min and maintain at this temperature for 4 h.
Step 4: Change the ambient temperature to 20 ℃ ± 5 ℃ within 30 min and maintain at this temperature for a minimum of 2 h.
Step 5: Repeat steps 1 to 4 for a further four cycles.
Step 6: After the fifth cycle, store the cells or RESS for seven days prior to examination.

NOTE: This test can be performed in a single chamber whose temperature is changed or in three separate chambers at three different test temperatures.

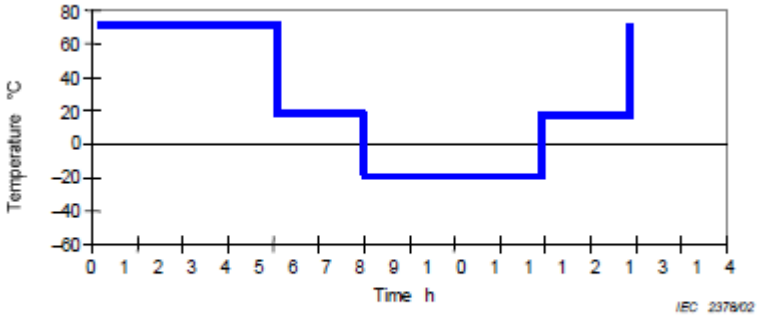


Figure 1 – Temperature profile for 4.2.4 – Temperature cycling test (one cycle)

The following test can be conducted with the RESS [or with module(s)] of the RESS.
[If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.]
Adjust the State of Charge (SOC) with discharge to [50 %] before starting the vibration test profile.

~~Before thermal shock cycling, the DUT capacity shall be evaluated by performing two standard cycles (SC) according to 6.2. Adjust the SOC with a 1C discharge to 50 % before starting the thermal shock cycling profile~~.

Start with the RESS at room temperature, contained in a closed volume and with all thermal controls disabled, thermally cycle the RESS with ambient temperature between 85 ℃ or T_{max} as specified between supplier and customer to -40 ℃ (the ambient temperature should be measured in close proximity to the RESS). The time to reach each temperature extreme shall be 30 min or less. If it is logistically possible, given equipment limitations and safety considerations, the RESS can be moved between two test chambers each set at the opposite end of the temperature range. The RESS shall remain at each extreme for a minimum of one hour. A total of five thermal cycles shall be performed. After thermal cycling, inspect the RESS for any damage, paying special attention to any seals that may exist. Verify that control circuitry is operational.

Suggests that two different types of testing is conducted as described in ISO16750-4 § 5.3, i.e. one cycling and one shock.
Operating temperature code G according to ISO 16750-4 or according to an agreement between the supplier and customer as specified in ISO 12405-1.
Important that temperature stability should be reached inside the object as specified in IEC 60068-2-14
SOC 50%,

UN Test procedure
i) ten cells at first cycle, in fully charged states;

(ii) four small batteries at first cycle, in fully charged states;
(iii) four small batteries after 50 cycles ending in fully charged states;

(iv) two large batteries at first cycle, in fully charged states; and
(v) two large batteries after 25 cycles ending in fully charged states.

Test cells and batteries are to be stored for at least six hours at a test temperature equal to 72 ± 2 ℃, followed by storage for at leas t six hours at a test temperature equal to - 40 ± 2 ℃. The maximum time interval bet ween test temperature extremes is 30 minutes. This procedure is to be repeated 10 times, after which all test cells and batteries are to be stored for 24 hours at ambient temperature (20 ± 5 ℃). For large cells and batteries the duration of exposure to the test temperature extremes should be at least 12 hours.

3.2.2.2 Acceptance criteria

No physical distortion of the RESS case resulting in exposure of internal components.

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test shall maintain high voltage to ground isolation no less than 100 Ω/Volt.

According to SAE- J2464, level 0. Function should be as defined in ISO 16750-1 class A after test.

Cells and batteries meet this requirement if there is

- no mass loss,
- no leakage,
- no venting,
- no disassembly,
- no rupture and
- no fire and
- if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure.

The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

3.2.3 Verification

Repeated exposure to high and low temperatures shall not cause fire or explosion.

a) to d) of 3.1.2.2 shall be checked by visible inspection.

The isolation resistance shall be measured according to Annex 1

Verification against acceptance criteria and according to ISO 12405-1 § 6.2

3.3 [~~Humidity / Moisture Exposure~~ Dewing (temperature change)

[ISO 12405-1]

3.3.1 Rationale

Simulates a temperature/humidity environment which a RESS will likely experience during its life (only for RESS above 60 VDC)

~~This test simulates the use of the system/component under high ambient humidity.~~

3.3.2 Requirement

REMARKS: Critical phenomenon most likely happens under the humidity test procedure is short circuit at external of the cell. Therefore, specific test procedure for humidity will not be necessary.

3.3.2.1 Conditions

The following test can be conducted with the RESS [or with module(s)] of the RESS.

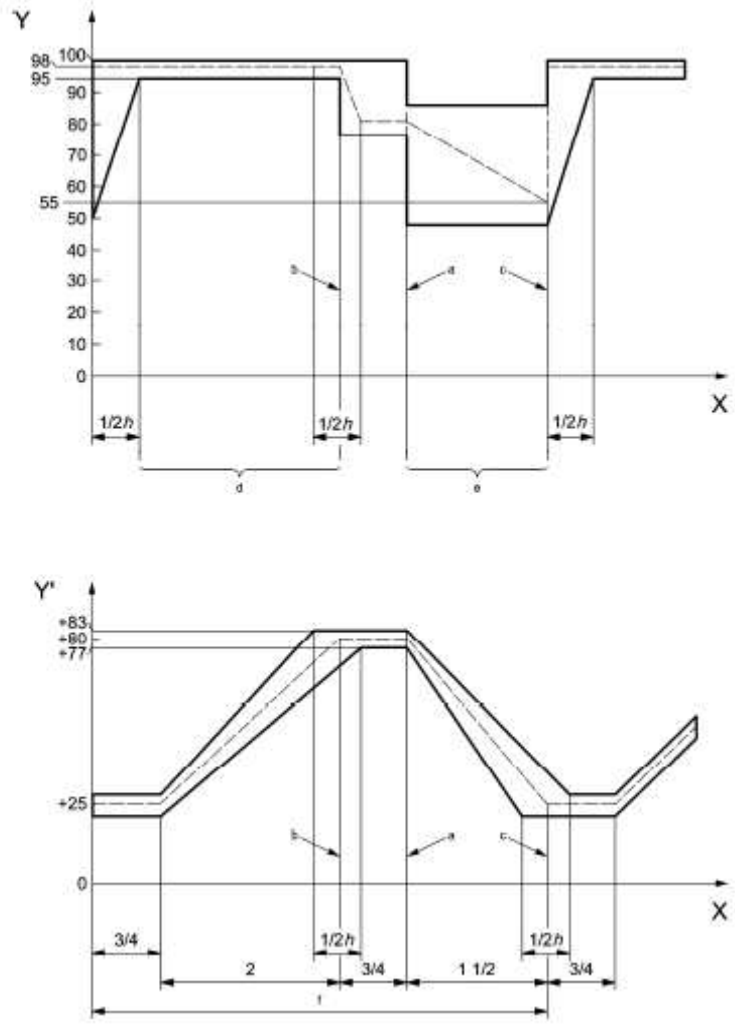
[If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.]

Adjust the State of Charge (SOC) with discharge to [50 %] before starting the vibration test profile.

Perform the test in reference to IEC 60068-2-30, Db, but: – Humidity and temperature profiles according to Figure 6. – number of cycles 5. Use operating mode 2.1 according to ISO 16750-1 during the complete test sequence. If the temperature of the RESS exceeds the limits given by the supplier the RESS should be operated in an operating mode as agreed between ~~customer and supplier~~ manufacturer and Technical Service.

NOTE: The temperature and humidity profile is specified to generate dewing affected like in the vehicle environment.

Figure 6 — Dewing cycle



Key:

Y = relative humidity in % RH
Y' = temperature in ℃
X = time
A = start of temperature fall
B = end of temperature rise
c = recommended set value humidity / temperature
d = condensation
e = drying
f = one cycle

According to ISO16750-4 § 5.6 test3 (same as in ISO 12405 but ISO 12405 is still a DIS).
SOC 50%,

3.3.2.2 Acceptance criteria

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test shall maintain high voltage to ground isolation no less than 100 Ω/Volt.

According to SAE- J2464, level 0. Function should be as defined in ISO 16750-1 class A after test.

3.3.3 Verification

a) to d) of 3.1.2.2 shall be checked by visible inspection.

The isolation resistance shall be measured according to Annex 1.

Verification against acceptance criteria and according to 12405-1 § 6.2

3.4 Mechanical impact

3.4.1 Mechanical Shock ((Enclosure Integrity may has to be considered) related to R94, R95, R12)

(SAE J 2464 + R110)

3.4.1.1 Rationale

Simulates inertial loads which may occur during vehicle crash situation to RESS

3.4.1.2 Requirement

~~REMARK: Test on vehicle should be examined at first and the test on RESS component should be developed as an alterative so that it can reasonably simulate the similar level of incident as such vehicle test conditions.~~

3.4.1.2.1 Conditions

~~Vehicle Test (M1, N1): R94, R95 and R12 should be reviewed (and revised as necessary) with respect to (a) the preparation before the test (e.g. state of charge of RESS) and (b) the pass/fail criteria (e.g. no fire).~~

~~Component Test: At the moment, there is no procedure sufficiently defined and validated by the international standardization bodies. Practicality on large battery pack should also be carefully considered.~~

~~The fully charged cell or RESS is secured to the testing machine by means of a rigid mount which will support all mounting surfaces of the cell or RESS. The cell or RESS is subjected to a total of three shocks of equal magnitude. The shocks are applied in each of three mutually perpendicular directions. At least one of them shall be perpendicular to a flat face. For each shock the cell or RESS is accelerated in such a manner that during the initial 3 milliseconds the minimum average acceleration is 75 gn. The peak acceleration shall be between 125 gn and 175 gn. Cells or RESS are tested in an ambient temperature of 20 °C ±5 °C.~~

The following test can be conducted with the RESS [or with module(s)] of the RESS. Alternatively, the RESS installed in a vehicle could be tested according to UNECE Reg.94 and 95.

A complete RESS is to be tested for this condition. However, if conducting this test on a RESS is deemed inappropriate due to size or weight, this test may be conducted utilizing battery subsystems / modules, provided that all portions of the battery system are evaluated. If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.

Module(s) have to be marked:

- For which vehicle category
- Installation direction

Adjust the State of Charge (SOC) with discharge to [50 %] before starting the impact test profile.
The RESS shall be applied to the shock levels and durations described in Table 5 and 6 in both positive and negative directions. The shock level is specified in terms

of a velocity change and a corresponding maximum duration. The shock duration is defined as the time between 10% and 90% of peak value. For every of the 4 evaluation conditions, a separate RESS can be used. The RESS shall be connected to the test fixture only by the intended mounting methods.

Table 5 – Shock levels and duration in direction of travel

	Acceleration	Duration	pulse form	total number of shocks
RESS fitted vehicles of categories M1 and N1	[20]g	15ms	half sine	2
RESS fitted vehicles of categories M2 and N2	[10]g	15ms	half sine	2
RESS fitted vehicles of categories M3 and N3	[6.6]g	15ms	half sine	2

Table 6 – Shock levels and duration in horizontally perpendicular to the direction of travel

	Acceleration	Duration	pulse form	total number of shocks
RESS fitted vehicles of categories M1 and N1	[8]g	15ms	half sine	2
RESS fitted vehicles of categories M2 and N2	[5]g	15ms	half sine	2
RESS fitted vehicles of categories M3 and N3	[5]g	15ms	half sine	2

~~According to ISO16750-3 §4.2.2 (same as in ISO 12405 but ISO 12405 is still a DIS).~~
~~SOC 50%,~~

3.4.1.2.2 Acceptance criteria

~~No fire, no explosion, no leakage.~~

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

The RESS shall be retained at its mounting locations and RESS components shall remain inside RESS boundaries.

~~After the test at least one of the following criteria specified in paragraph ???. and ?? shall be met.~~

~~!Requirements regarding RESS retention according to R94/95 to be defined!~~

~~According to SAE- J2464, level 0. Function should be as defined in ISO 16750-1 class A after test.~~

3.4.1.3 Verification

Shocks encountered during handling or transportation shall not cause fire, explosion or leakage.

a) to d) of 3.4.1.2.2 shall be checked by visible inspection.

~~???.~ ???.~~ ~~shall be measured according Annex ??? paragraph ???.~~

Verification against acceptance criteria and according to 12405-1 § 6.2

3.4.2 Mechanical integrity

3.4.2.1 Rationale

Simulates contact loads which may occur during vehicle crash situation to RESS

3.4.2.2 Requirement

REMARK: Test on vehicle should be examined at first and the test on RESS component should be developed as an alterative so that it can simulate the similar level of incident as such vehicle test conditions.

3.4.2.2.1 Conditions

Vehicle Test (M1, N1): R94, R95 and R12 should be reviewed (and revised as necessary) with respect to (a) the preparation before the test (e.g. state of charge of RESS) and (b) the pass/fail criteria (e.g. no fire).
Component Test: At the moment, there is no procedure sufficiently defined and validated by the international standardization bodies. Practicality on large battery pack should also be carefully considered.

[Conditions considering different road vehicles of categories M and N are to be defined]

3.4.2.2.2 Acceptance criteria

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

After the test at least one of the following criteria specified in paragraph ??? and ??shall be met.

[Requirements regarding RESS retention according to R94/95 to be defined]

3.4.2.3 Verification

[Verification method considering different road vehicles of categories M and N are to be defined]

~~3.4.3 Crash Test~~
~~((Enclosure Integrity may has to be considered) related to R94, R95, R12)~~

~~3.4.3.1 Rationale~~
~~Simulates inertial loads which may occur during vehicle crash situation to RESS~~

~~3.4.3.2 Requirement~~
~~3.4.3.2.1 Conditions~~
~~3.4.3.2.2 Acceptance criteria~~
~~According to SAE- J2464, level 2 or 3.~~

~~3.4.3.3 Verification~~

3.5 [Fire Resistance

3.5.1 Rationale

Simulates exposure of RESS to fire from the outside or vehicle fire to the RESS

3.5.2 Requirement

3.5.2.1 Conditions

Similar to R34 for cases where the RESS casing cannot build up pressures.

For cases where the casing can build up pressures a test similar to R67 and 110 should be developed. These tests are however not so well described and gives room for a large variety of interpretations.

Another option is to look at the SAE J2929 when it is available.

R34 Annex 5 can be the basis of the test procedure while the details of test procedure need to be defined. Since the test will normally be conducted open air condition, there are some concerns about the repeatability due to the change of weather.
R67/R110 will not be a good reference because RESS will not be designed as pressure vessels.

3.5.2.2 Acceptance criteria

[Within [1] hour after the fire exposure no “RESS-caused-fire”, ~~No re-restarting contribution to of the fire (R34),~~ No leakage(R34), No explosion (pressure buildup casings)]

3.5.3 Verification

Against acceptance criteria**]**

3.6 External Short Circuit (related to R100)

(ISO 12405-1)

3.6.1 Rationale

~~[Verify functionality of over current protection in presence of a short circuit external to the RESS]~~

The purpose of the short circuit protection test it is to check the functionality of the over-current protection de-vice. This device shall interrupt the short circuit current in order to prevent the RESS from further related severe events caused by a short circuit current.

Short circuit inside the battery pack, but external of cell, should also be verified.

3.6.2 Requirement

The short circuit inside the battery pack can be verified by the test under R94, R95 and R12.

3.6.2.1 Conditions

Two sets of fully charged ~~cells or~~ RESS are stored in an ambient temperature of 20 ℃ ± 5 ℃ a~~nd 55 ℃ ± 5 ℃~~ respectively. Each ~~cell or~~ RESS is then short-circuited by connecting the positive and negative terminals with a total external resistance of less than 100 mΩ. The cells or RESS remain on test for 24 h or until the case temperature declines by 20 % of the maximum temperature rise, whichever is the sooner. (=> out of IEC 61223)

Test T.5: External short circuit

38.3.4.5.1 Purpose

This test simulates an external short circuit.

38.3.4.5.2 Test procedure

The ~~cell~~ or battery to be tested shall be temperature stabilized so that its external case temperature reaches ~~55 ± 2 ℃~~ and then the cell or battery shall be subjected to a short circuit condition with a total external resistance of less than 0.1 ohm at ~~55 ± 2 ℃.~~ This short circuit condition is continued for at least one hour after the cell or battery external case temperature has returned to ~~55 ± 2 ℃~~. The cell or battery must be observed for a further six hours for the test to be concluded.

38.3.4.5.3 Requirement

Cells and batteries meet this requirement if their external temperature does not exceed

170 ℃ and there is no disassembly, no rupture and no fire within six hours of this test.

The following test can be conducted with the RESS [~~or with module(s)~~] of the RESS.

[If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.]

The RESS shall be at RT, fully charged and under normal operating conditions (main contactors are closed, battery systems are controlled by the BCU).

An appropriately sized conductor of (100 +0/-40) mΩ shall be used to apply a 'hard short' in less than one second for 10 min, or until another condition occurs that prevents completion of the test (e.g., component melting). The test shall be performed with integrated passive and non-passive short circuit protection devices operational.

According to ISO 12405-1 § 9.2.2

3.6.2.2 Acceptance criteria

No fire, no explosion.

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test shall maintain high voltage to ground isolation no less than 100 Ω/Volt.

Severity level 2 or 3 and ISO 12405-1 § 9.2.2 and § 9.2.3
SAE J 2464 is more detailed and has several criteria. Some of them are however difficult to conduct

3.6.3 Verification

Short-circuiting of the positive and negative terminals shall not cause fire or explosion.

a) to d) of 3.1.2.2 shall be checked by visible inspection.

The isolation resistance shall be measured according to Annex 1.

Against acceptance criteria, ISO 12405-1 9.2.3 and § 6.2
SAE J 2464 is more detailed and has several criteria. Some of them are however difficult to conduct

3.7 Overcharge Protection

(=> ISO 12405-1)

3.7.1 Rationale

~~Verify functionality of the overcharge protection~~

The purpose of the overcharge protection test it is to check the functionality of the overcharge protection function. This function shall interrupt the overcharge current in order to prevent the RESS from any further related severe events caused by an overcharge current.

REMARKS: UN38.3 will not be sufficient to assess the functionality of the vehicle system.

3.7.2 Requirement

3.7.2.1 Conditions

The following test can be conducted with the RESS [or with module(s)] of the RESS.
[If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.]

The RESS shall be at RT, fully charged and under normal operating conditions with the cooling system operating (main contactors are closed if any; battery system is controlled by the BCU). The test shall be performed with integrated passive circuit protection devices operational. Active charge control of the test equipment shall be disconnected.
The RESS shall be charged at a constant current rate which is agreed by manufacturer ~~supplier~~ and Technical Service ~~customer~~. ~~The recommended constant charge current should be 5C. – The upper limit for the power-supply voltage should be set not to exceed 20 % of the maximum battery system voltage~~. − Charging shall be continued

- until the DUT automatically interrupt the charging or
- [until limits for SOC and DUT cell temperature levels reached which are agreed between manufacturer ~~supplier~~ and Technical Service ~~customer.~~]

~~by an automatic disconnect of the main contactors.– The overcharge test shall be terminated when the SOC level is above 130 % or when cell temperature levels are above 55 °C.~~

[Limits for SOC and DUT cell temperature levels for premature abortion of ~~terminating~~ the over-charge protection test may be agreed between manufacturer ~~supplier~~ and Technical Service ~~customer.~~ => May be part of the information document see annex 6 of ECE R100]

According to ISO 12405-1 § 9.3.2

3.7.2.2 Acceptance criteria

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test shall maintain high voltage to ground isolation no less than 100 Ω/Volt.

[[1] after the test the RESS shall be re-used]

Severity level 2 or 3 and ISO 12405-1 § 9.3.2 and § 9.3.3
SAE J 2464 is more detailed and has several criteria. Some of them are however difficult to conduct

3.7.3 Verification

a) to d) of 3.1.2.2 shall be checked by visible inspection.

The isolation resistance shall be measured according to Annex 1.

Against acceptance criteria, ISO 12405-1 9.3.3 and § 6.2
SAE J 2464 is more detailed and has several criteria. Some of them are however difficult to conduct

3.7.4 [Overcharge for nickel systems => 3.7.2.1

3.7.4.1 Conditions

A discharged cell or a battery ~~RESS~~ is subjected to a high-rate charge of 2,5 times the recommended charging current for a time that produces a 250 % charge input (250 % of rated capacity).

3.7.4.2 Acceptance criteria

Charging for longer periods and at a higher rate than specified by the manufacturer shall not cause fire or explosion.

3.7.4.3 Verification

No fire, no explosion.

3.7.5 Overcharge for lithium systems => 3.7.2.1

3.7.5.1 Conditions

The cell is discharged as described in IEC 61960, then charged from a power supply of 10 V, at the charging current I_{rec}, recommended by the manufacturer, for 2,5 C5/I_{rec} h.

3.7.5.2 Acceptance criteria

Charging for longer periods than specified by the manufacturer shall not cause fire or explosion.

3.7.5.3 Verification

No fire, no explosion.]

3.8 Over-discharge Protection

(ISO 12405-1)

3.8.1 Rationale

Verify functionality of the over-discharge protection and /or protect an over-discharged battery to be charged.

The purpose of the over-discharge protection test it is to check the functionality of the over-discharge protection function. This device shall interrupt the over-discharge current in order to prevent the DUT from any further related severe events caused by an over-discharge current.

REMARKS: UN38.3 will not be sufficient to assess the functionality of the vehicle system.

3.8.2 Requirement

3.8.2.1 Conditions

~~A discharged cell is subjected to a reverse charge at 1 It A for 90 min.~~

[For RESS which do not need an over-discharge protection the manufacturer shall demonstrate to provide evidence to the Technical Service which shows that any over-discharge and standard charge afterwards does not lead to any situation described in the acceptance criteria.]

For RESS which need an over-discharge protection the following test shall ~~can~~ be conducted with the RESS [or with module(s)] of the RESS.

[If tests are performed on module basis, evidence shall be provided that the results are representative for RESS.]

The RESS shall be at RT, ~~fully charged and~~ charged as under normal operating conditions with the cooling system operating (main contactors are closed if any, battery system are controlled by the BCU). The test shall be performed with integrated passive circuit protection devices operational. Active discharge control of the test equipment shall be disconnected.

Perform a standard discharge. When reaching the normal discharge limits, discharging with 1C rate shall be continued.

Discharging shall be continued until the RESS interrupt the discharging automatically. ~~by an automatic disconnect of the main contactors~~.

~~The discharge test shall be terminated manually if 25 % of the nominal voltage level or a time limit of 30 min after passing the normal discharge limits of the RESS have been achieved. Values for time and voltage limits for terminating the over-discharge protection test may be agreed between supplier and customer.~~

~~NOTE Nominal voltage is the voltage given by the supplier as the recommended operating voltage of their battery system. Voltage depends on chemistry, cell numbers and arrangement of cells.~~

Direct after the over-discharging a standard charging has to be conducted if not inhibited by the system.

According to ISO 12405-1 § 9.4.2

3.8.2.2 Acceptance criteria

~~A cell in a multi-cell application shall withstand polarity reversal without causing fire or explosion.~~

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

For RESS using high voltage the isolation resistance measured at the end of the test shall maintain high voltage to ground isolation no less than 100 Ω/Volt.

Severity level 2 or 3 and ISO 12405-1 § 9.4.2 and § 9.4.3
SAE J 2464 is more detailed and has several criteria. Some of them are however difficult to conduct

3.8.3 Verification

~~No fire, no explosion.~~

[a) to d) of 3.1.2.2 shall be checked by visible inspection.]

The isolation resistance shall be measured according to Annex 1.

Against acceptance criteria, ISO 12405-1 $9.4.3 and $6.2
SAE J 2464 is more detailed and has several criteria. Some of them are however difficult to conduct

3.9 Over-temperature Protection (related to R100)

~~=> Adressed by paragraph 3.6 external short circuit.~~

3.9.1 Rationale

Verify the functionality that prevents the operation at over-temperatures inside the RESS

3.9.2 Requirement

At the moment, there is no procedure sufficiently defined and validated by the international standardization bodies. Subjective requirement will be sufficient.

3.9.2.1 Conditions

An over-temperature situation has to be "generated"
It has to be checked / demonstrated that the battery cannot be operated.

~~[Each fully charged cell, stabilized at room temperature, is placed in a gravity or circulating air-convection oven. The oven temperature is raised at a rate of 5 °C/min ± 2 °C/min to a temperature of 130 °C ± 2 °C.~~

~~The cell remains at this temperature for 10 min before the test is discontinued.]~~

3.9.2.2 Acceptance criteria

~~An extremely high temperature shall not cause fire or explosion.~~

During the test, including [1] h after the test, the battery system shall exhibit no evidence

a) of undefined visible venting or
b) battery enclosure rupture (no degradation of protection degree) or
c) fire or
d) explosion.

3.9.3 Verification

~~No fire, no explosion.~~

[a) to d) of 3.9.2 .2 shall be checked by visible inspection.]

3.10 Protection against direct contact (related to R100)

3.10.1 Rationale

Verify the functionality that protects persons to come in contact with high voltage live parts (only for RESS above 60 VDC). This requirement has to be proved under ECE R100.

~~**3.10.2 Requirement**~~

~~**REMARK: For vehicle approval, R100 will be sufficient.**~~

~~**3.10.2.1 Conditions**~~

~~ISO/DIS 6469-3 clause 7~~

~~**3.10.2.2 Acceptance criteria**~~

~~ISO/DIS 6469-3 clause 7~~

~~**3.10.3 Verification**~~

~~ISO/DIS 6469-3 clause 7~~

3.11 [Emission (May also be part of abnormal situations like Fire Resistance etc.) and/or ECE R100 (normal use)

3.11.1 Rationale

[Emission of gases during normal use]

REMARK: For vehicle approval, R100 will be sufficient.

3.11.2 Requirement

For open type traction batteries hydrogen emissions are possible (see ECE R100)
For all other RESS designs no “hazardous” emissions are allowed under normal use.

3.11.2.1 Conditions

3.11.2.2 Acceptance criteria

3.11.3 Verification]

3.12 Over current charge and discharge

3.12.1 Rationale

Verify protection against over-current charge and discharge

REMARK: The phenomena caused by over current charge can be assessed by overcharge protection and over temperature protection. Over current discharge will happen only in the case of external short circuit.

3.12.2 Requirement

3.12.2.1 Conditions

The cell is discharged as described in IEC 61960, then charged at three times the charging current recommended by the manufacturer, until the cell is fully charged or an internal safety device cuts off the charge current before the cell is fully charged.

3.12.2.2 Acceptance criteria

A cell shall not cause fire or explosion if a charger malfunctions or if excess current flows in a parallel cell assembly pack.

3.12.3 Verification

No fire, no explosion.

~~3.13 [Short circuit (internal)~~
~~3.13.1 Rationale~~
~~Test RESS response to short circuit of one or several cells~~

~~3.13.2 Requirement~~
~~According to the working document for the 38th session of ECOSOC Sub-Committee of Experts on the Transport of Dangerous Goods (TDG), the test procedure simulating cell internal short circuit is not available yet. (ref. para. 5 (b) of ST/SG/AC.10/C.3/2010/81.)~~
~~This issue should be addressed at a later phase.~~

~~3.13.2.1 Conditions~~
~~3.13.2.2 Acceptance criteria~~

~~3.13.3 Verification]~~

B) ADDITIONAL REQUIREMENTS?

IMMERSION TEST (RESS COMPLETE UNDER WATER)
Rationale for the necessity maybe by NL.
Flooded roads are common in other areas also. A test is specified in SAE J2464.

REMARK: Immersion will not cause any safety critical phenomena for RESS.

[DUST]

MARKING
ISO 6469-3 and R100

EMC
R10

Tell-tale