

Vibration

EVS-GTR 18th

China
2019.06

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China position on vibration test condition

- We believe that vibration is closely related to the safety of electric vehicles and should be included in GTR.
- As a high voltage energy storage system, generally vibration causes structural and connection damage to the battery pack, which can further cause external short circuits and eventually leads to safety problems.
- Based on the vibration methods in the existing regulations, we recommend modifying the existing test methods:
 - Modify the test method based on the road spectrum acquired from actual vehicle test data.
 - Give guidelines for using manufacture's profile.

Technical rationale and justification

➤ **The purpose of vibration test, completely consistent.**

GTR No. 20

130. The purpose of this test is to verify the safety performance of the REESS under a vibration environment which the REESS would likely experience during the normal operation of the vehicle.

China proposal

130. The purpose of this test is to verify the safety performance of the REESS under a vibration environment which the REESS would likely experience during the normal operation of the vehicle.

No change

Technical rationale and justification

➤ The introduction to vibration method, was revised

GTR No. 20

131. A vibration load spectrum for lithium cells and batteries including lithium ion cells/batteries and lithium polymer cells/batteries is already defined as a type approval test procedure of dangerous goods of class 9 in the Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, paragraph 38.3.4.3. (Test T3: Vibration), with an amplitude sweep ranging from 7 Hz to 200 Hz.

132. As Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria sign-off may often also be mandatory for types of REESS (such as lithium metal batteries, lithium ion batteries and lithium polymer batteries) subject to this regulation, having the opportunity to cover this test with test T3, is seen as an efficient approach.

133. However, the load curve per Test T3 is assessed as too severe for automotive applications. Despite the recent lowering of the high frequency amplitude in Test T3 from 8g to 2g for "large batteries" with masses more than 12 kg, even this amplitude is still not considered representative for the typical sizes of REESS in vehicles, with a mass of 200 kg or more. Particularly, the height of the amplitudes above 18 Hz is seen as unrealistic and does not correlate to the loads seen in road vehicles (except for hypothetical cases of REESS mounted close to or onto a combustion engine). Due to the stiffness of vehicle bodies in relation to the module weight frequencies, frequencies higher than 18Hz cannot be transmitted at significant energy levels.

134. This UN GTR, therefore, uses the same frequency vertices as Test T3, albeit those for smaller cells, but lowers the load curve above 18Hz and truncates it at 50Hz.

135. The test duration is also aligned with Test T3, requiring 12 transitions from the minimum to the maximum frequency and back within 15 min., resulting in a total test duration of 3 hours.

136. While Test T3 requires the test to be performed in all three spatial directions, in vehicle applications this load occurs in the vertical direction only, while the longitudinal and lateral vehicle dynamic loads are significantly lower. The vibration test therefore needs to be performed in the vertical installation direction only. When utilizing this option, the orientation of the REESS in the vehicle must be restricted accordingly; this information shall be communicated to the regulating entity by the vehicle manufacturer. The administrative procedures to ensure such a communication will be specified by the regulating Contracting Party.

China proposal

131. The vibration of the battery pack is caused by the random vibration of the vehicle during operation. So the actual vehicle operation data should be used to develop the vibration spectrum of the battery pack. Specifically, different types of vehicles were tested on typical road surfaces. The vibration spectrum is obtained by analyzing and normalizing the collected data.

□ *Research results were presented in previous last two meeting :*

- *EVS16-E4VP-0100 [CN]EVS-GTR vibration load proposal*
- *EVS16-E4VP-0200 [CN]REESS vibration test method proposal*
- *EVS17-E4VP-0100 [CN]REESS vibration profile research*

Technical rationale and justification

➤ **The manufacturer method should be accepted, but need to make some modifications.**

GTR No. 20

137. In many cases, the vehicle manufacturer assesses the vehicle's durability with full vehicle simulation, either by running a rough road test track or by simulating the lifetime fatigue on a 4-poster vibration rig. These methods provide a vehicle specific assessment of the durability of all vehicle components and should be accepted in this context.

China proposal

132. In many cases, the vehicle manufacturer assesses the vehicle's durability with full vehicle simulation, either by running a rough road test track or by simulating the lifetime fatigue on a 4-poster vibration rig. These methods provide a vehicle specific assessment of the durability of all vehicle components and should be accepted in this context.

Guidelines for using manufacture's profile should be given. (In research)

Technical rationale and justification

➤ A standard cycle after vibration, deleted as it is not about safety.

GTR No. 20

138. To finalize the certification of the REESS, a standard cycle has to be performed, to verify that the mechanical loads have not had any negative effect on the electrical function.

China proposal

~~138. To finalize the certification of the REESS, a standard cycle has to be performed, to verify that the mechanical loads have not had any negative effect on the electrical function.~~

Requirement and test procedure

GTR No. 20

□ Requirement

The test shall be conducted in accordance with paragraph 6.2.2. During the test, there shall be no evidence of rupture (applicable to high voltage REESS only), electrolyte leakage, venting (for REESS other than open-type traction battery), fire or explosion.

The evidence of electrolyte leakage shall be verified by visual inspection without disassembling any part of the Tested-Device. An appropriate technique shall, if necessary, be used in order to confirm if there is any electrolyte leakage from the REESS resulting from the test. The evidence of venting shall be verified by visual inspection without disassembling any part of the Tested-Device.

For a high voltage REESS, the isolation resistance measured after the test in accordance with paragraph 6.1.1. shall not be less than 100 Ω/V .

China proposal

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For a high voltage REESS, the isolation resistance measured after the test in accordance with paragraph 6.1.1 shall not be less than 100 Ω/V .

No change

Requirement and test procedure

GTR No. 20

□ Test procedure

6.2.2.1. Purpose.

The purpose of this test is to verify the safety performance of the REESS under a vibration environment which the REESS will likely experience during the normal operation of the vehicle.

6.2.2.2. Installations.

6.2.2.2.1. This test shall be conducted either with the complete REESS or with REESS subsystem(s). If the manufacturer chooses to test with REESS subsystem(s), the manufacturer shall demonstrate that the test result can reasonably represent the performance of the complete REESS with respect to its safety performance under the same conditions. If the electronic management control unit for the REESS is not integrated in the casing enclosing the cells, then the electronic management unit may be omitted from installation on the Tested Device if so requested by the manufacturer.

No change

China proposal

□ Test procedure

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Requirement and test procedure

GTR No. 20

□ Test procedure

6.2.2.2.2. The Tested-Device shall be firmly secured to the platform of the vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the Tested-Device.

The Test-Device should be mounted with its original mounting points and holders as mounted in the vehicle. The holders should be firmly secured to the platform of the vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the holders of the Tested-Device.

China proposal

□ Test procedure

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The Test-Device should be mounted with its original mounting points and holders as mounted in the vehicle. The holders should be firmly secured to the platform of vibration machine in such a manner as to ensure that the vibrations are directly transmitted to the holders of the Tested-Device.

No change

Requirement and test procedure

GTR No. 20

□ Test procedure

6.2.2.3. Procedures.

6.2.2.3.1. General test conditions.

The following conditions shall apply to the Tested-Device:

- (a) The test shall be conducted at an ambient temperature of 22 ± 5 ° C ;
- (b) At the beginning of the test, the SOC shall be adjusted in accordance with the paragraph 6.2.1.2.;
- (c) At the beginning of the test, all protection devices which affect the function(s) of the Tested-Device that are relevant to the outcome of the test shall be operational.

China proposal

□ Test procedure

6.2.2.3. Procedures.

6.2.2.3.1. General test conditions.

The following conditions shall apply to the Tested-Device:

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No change

Requirement and test procedure

GTR No. 20

□ Test procedure

6.2.2.3.2. Test procedures.

The Tested-Device shall be subjected to a vibration having a sinusoidal waveform with a logarithmic sweep between 7 Hz and 50 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours in the vertical direction of the mounting orientation of the REESS as specified by the manufacturer. The correlation between frequency and acceleration shall be as shown in Table 2:

Table 2
Frequency and acceleration

Frequency (Hz)	Acceleration (m/s ²)
7 - 18	10
18 - 30	gradually reduced from 10 to 2
30 - 50	2

China proposal

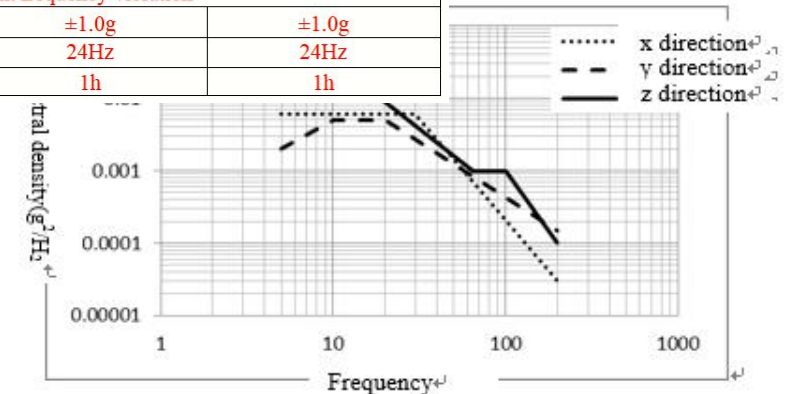
□ Test procedure

6.2.2.3.2. Test procedures

For REESS or REESS subsystem(s) on vehicles of classes M1 and N1, the vibration test parameters shall be based on Table 1 and Figure 1.

Table 1 Vibration test conditions for battery packs or systems on vehicles of Classes M₁ and N₁

Random vibration			
Frequency Hz	Power spectral density (PSD) of z axis, g ² /Hz	Power spectral density (PSD) of y axis, g ² /Hz	Power spectral density (PSD) of x axis, g ² /Hz
5	0.015	0.002	0.006
10	/	0.005	/
15	0.015	/	/
20	/	0.005	/
30	/	/	0.006
65	0.001	/	/
100	0.001	/	/
200	0.0001	0.00015	0.00003
RMS	0.64g	0.45g	0.50g
Time	12h	12h	12h
Sinusoidal constant frequency vibration			
Amplitude	±1.5g	±1.0g	±1.0g
Frequency	24Hz	24Hz	24Hz
Time	1h	1h	1h



Requirement and test procedure

GTR No. 20

□ Test procedure

China proposal

□ Test procedure

During the test, the cell voltage and temperature shall be monitored.

Note: termination condition of sharp voltage change provided by the manufacturer, where a test terminated based on using such a condition shall be treated as to fail.

If the test subject has multiple mounting directions (x/y/z), the test shall be performed in the direction with the largest RMS. For battery packs or systems mounted on the vehicle top, the test shall be performed under the vibration test parameters provided by the manufacturer (but not less than those in Table 1 and Figure 1).

Requirement and test procedure

GTR No. 20

□ Test procedure

At the request of the manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

At the choice of the manufacturer, a vibration test profile determined by the vehicle manufacturer verified for the vehicle application may be used as a substitute for the frequency - acceleration correlation of Table 2. The REESS certified according to this condition shall be limited to the installation for a specific vehicle type.

After the vibration profile, a standard cycle as described in paragraph 6.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

China proposal

□ Test procedure

At the request of the manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

At the choice of the manufacturer, a vibration test profile determined by the vehicle manufacturer verified for the vehicle application may be used as a substitute for the frequency - acceleration correlation of **Table 1**. The REESS certified according to this condition shall be limited to the installation for a specific vehicle type.

~~After the vibration profile, a standard cycle as described in paragraph 6.2.1.1. shall be conducted, if not inhibited by the Tested-Device.~~

The test shall end with an observation period of **2 hour** at the ambient temperature conditions of the test environment.

Requirement and test procedure

GTR No. 20

□ Test procedure

8.2.2.3.2. Test procedures.

The Tested-Device shall be subjected to a vibration having a sinusoidal waveform with a logarithmic sweep between 7 Hz and 50 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours in the vertical direction of the mounting orientation of the REESS as specified by the manufacturer.

The correlation between frequency and acceleration shall be as shown in Table 6.

Table 6
Frequency and acceleration

Frequency (Hz)	Acceleration (m/s^2)
7-18	10
18 - 30	gradually reduced from 10 to 2
30 - 50	2

China proposal

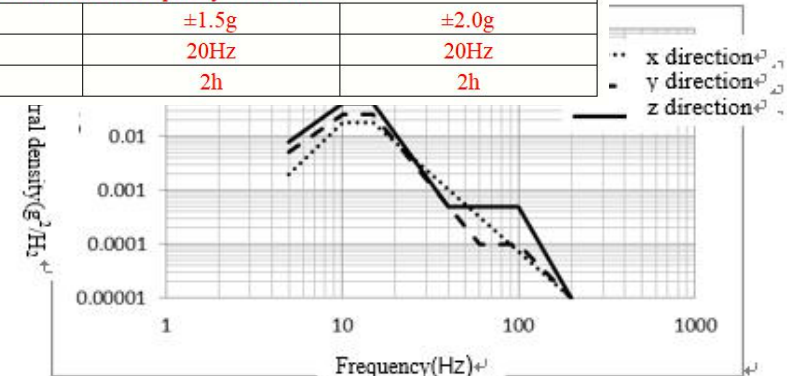
□ Test procedure

8.2.2.3.2. Test procedures

For REESS or REESS subsystem(s) on vehicles other than Classes M1 and N1, the vibration test parameters shall be based on Table 2 and Figure 2.

Table 2 Vibration test conditions for battery packs or systems on vehicles other than Classes M₁ and N₁

Random vibration			
Frequency Hz	Power spectral density (PSD) of z axis, g^2/Hz	Power spectral density (PSD) of y axis, g^2/Hz	Power spectral density (PSD) of x axis, g^2/Hz
5	0.008	0.005	0.002
10	0.042	0.025	0.018
15	0.042	0.025	0.018
40	0.0005	/	/
60	/	0.0001	/
100	0.0005	0.0001	/
200	0.00001	0.00001	0.00001
RMS	0.73g	0.57g	0.52g
Time	12h	12h	12h
Sinusoidal constant frequency vibration			
Amplitude	±1.5g	±1.5g	±2.0g
Frequency	20Hz	20Hz	20Hz
Time	2h	2h	2h



Requirement and test procedure

GTR No. 20

□ Test procedure

China proposal

□ Test procedure

During the test, monitor the state of the minimum monitoring unit in the test subject, such as voltage and temperature.

Note: termination condition of sharp voltage change provided by the manufacturer, where a test terminated based on using such condition shall be judged to fail.

If the test subject has multiple mounting directions (x/y/z), the test shall be performed in the direction with the largest RMS. For battery packs or systems mounted on the vehicle top, the test shall be performed under the vibration test parameters provided by the manufacturer (but not less than those in Table 2 and Figure 2).

Requirement and test procedure

GTR No. 20

□ Test procedure

At the request of the manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

At the choice of the manufacturer, a vibration test profile determined by the vehicle manufacturer verified for the vehicle application may be used as a substitute for the frequency - acceleration correlation of Table 6. The REESS certified according to this condition shall be limited to the installation for a specific vehicle type.

After the vibration profile, a standard cycle as described in paragraph 8.2.1.1. shall be conducted, if not inhibited by the Tested-Device.

The test shall end with an observation period of 1 hour at the ambient temperature conditions of the test environment.

China proposal

□ Test procedure

At the request of the manufacturer, a higher acceleration level as well as a higher maximum frequency may be used.

At the choice of the manufacturer, a vibration test profile determined by the vehicle manufacturer verified for the vehicle application may be used as a substitute for the frequency - acceleration correlation of **Table 2**. The REESS certified according to this condition shall be limited to the installation for a specific vehicle type.

~~After the vibration profile, a standard cycle as described in paragraph 8.2.1.1. shall be conducted, if not inhibited by the Tested-Device.~~

The test shall end with an observation period of **2 hour** at the ambient temperature conditions of the test environment.

Thanks for your attention!