Vibration requirements in GTR 20

Outline

1. General recommendation
2. Start of the art
3. New vibration profile
4. Justification

Vibration requirements in GTR 20: General recommendation

General observation:

Field experience shows that vibration requirement as safety requirements are not necessary

Reason:

No known field problems due to vibration

General Recommendation:

Preferred OICA position: eliminate vibration requirements from GTR 20

Alternative OICA position: make vibration requirements a Contracting Party option in GTR 20. And if a CP chooses for inclusion of vibration requirements in the national legislation, it is recommended to do it in the way it is proposed in the following slides and with the pass/fail criteria as defined in GTR 20 Phase 1.

Vibration requirements in GTR 20: New vibration profile 1

In general, OICA members want to **maintain the flexibility to use vehicle-specific test procedures** as it is allowed in current regulations.

However, since vehicle-specific tests might not always be possible for various reasons, it is agreed to introduce **a general minimum test profile with given values as an alternative for the vehicle/REESS manufacturers**. This profile would be a common profile for all REESS.

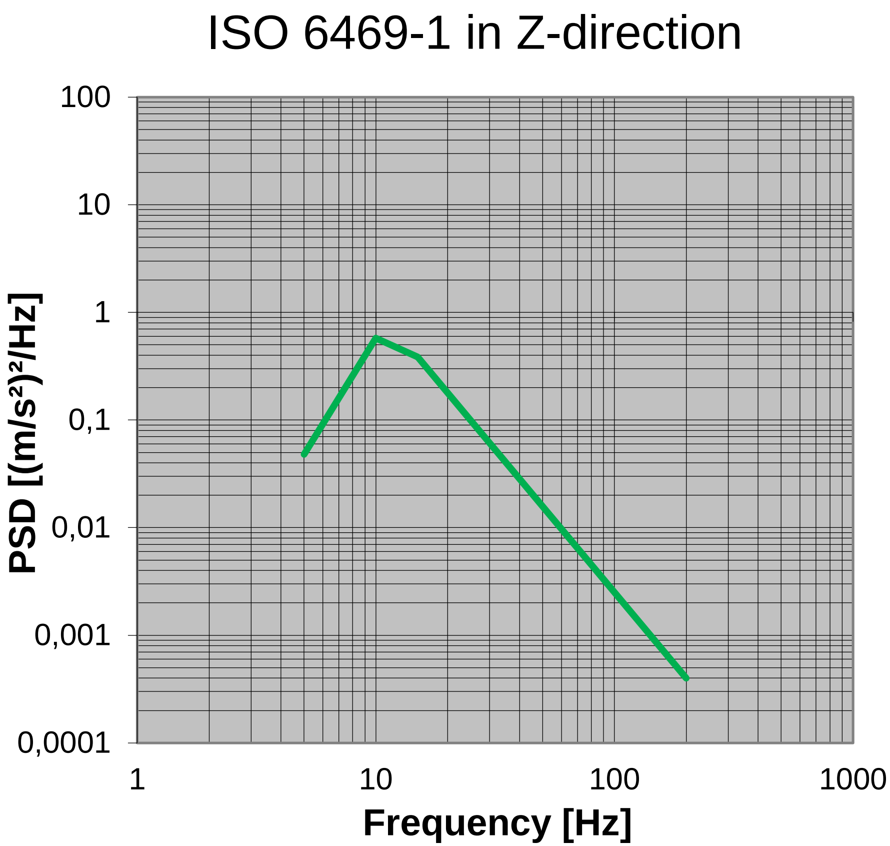
A minimum safety profile should avoid unnecessary weight, volume and costs for REESS.

Design concept for new mechanical safety profile
Option 1: Safety profile with given values below the level of durability testing
Option 2: Profile based on vehicle measurements

The new profile is appropriate for detection of e.g. following damage mechanisms:
- early detection of conceptual design failures of REESS
- early cracks in housing
- design failures of mechanical connections and fixations (e.g. loosening of connections)

Please note: pass/fail criteria should remain as already stated in GTR 20 Phase 1.

Vibration requirements in GTR 20: New vibration profile 2 (under investigation)

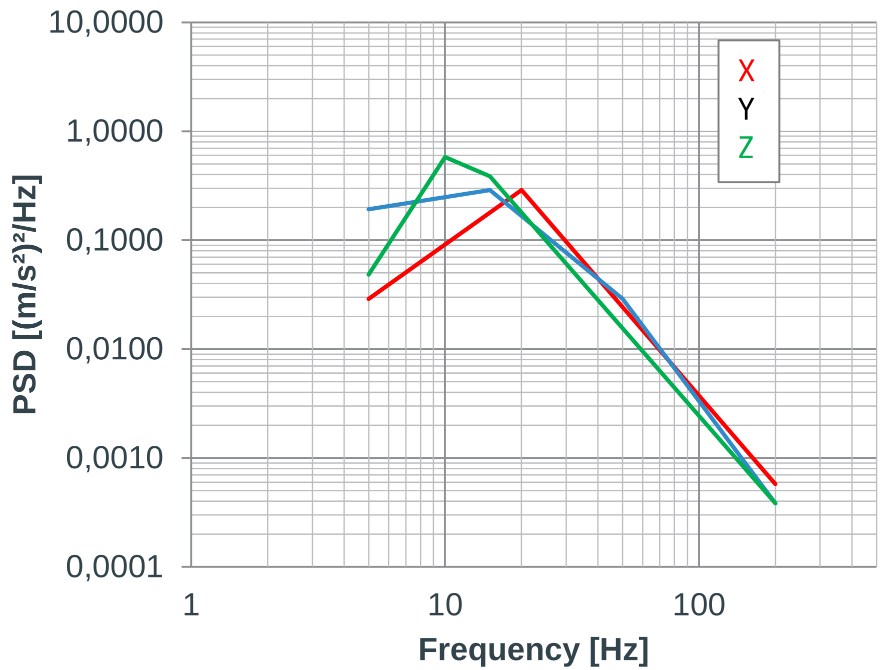


Note: 200 Hz are too high for heavy-duty vehicles and possibly also for future heavier battery packs in normal EVs.
A modified profile is under investigation.

***1:** vibration in z-direction only

Vibration requirements in GTR 20: New vibration profile 3

The proposed test profile:



X		Y		Z	
Hz	(m/s²)²/Hz	Hz	(m/s²)²/Hz	Hz	(m/s²)²/Hz
5	0,0289	5	0,1925	5	0,0481
20	0,2887	15	0,2887	10	0,5774
200	0,0006	50	0,0289	15	0,3849
		200	0,0004	200	0,0004

Vibration requirements in GTR 20: New vibration profile 4

<u>Test conditions:</u>

- the DUT shall be mounted on a test bench without brackets

- the whole test shall be conducted with the ***same DUT***

- the testing order shall be decided upon by an agreement between the customer and supplier

- the test shall be conducted with three spatial directions in the following order: Z-, X-, Y-direction.
  Please note: Alternatively a multi-axial type of test should also be allowed.

- the ambient temperature during the test shall be (20 ± 10) °C

- before the test, the SOC of the DUT shall be set to a value of at least 50 % of SOC range at normal operation.

- no electrical operation of RESS during the test.

Vibration requirements in GTR 20: Justification 1

The proposed procedure is specifically directed to safety requirements

The new procedure includes:

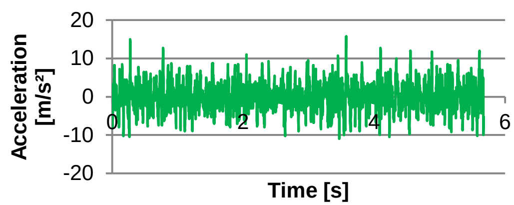
- Noise profile
- Testing in three spatial directions (X, Y, Z)
- Frequency interval up to 200 Hz (*only where appropriate*)

Comparison to ECE R100 profile/current GTR 20 profile:

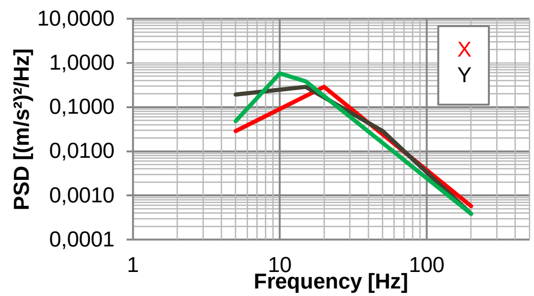
Current profile has only sinus sweep, only Z-direction and only 50Hz interval.

Vibration requirements in GTR 20: Justification 2

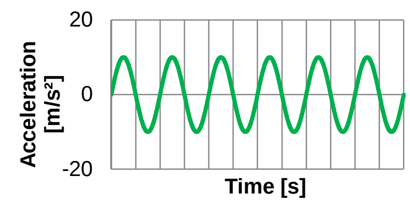
New Profile



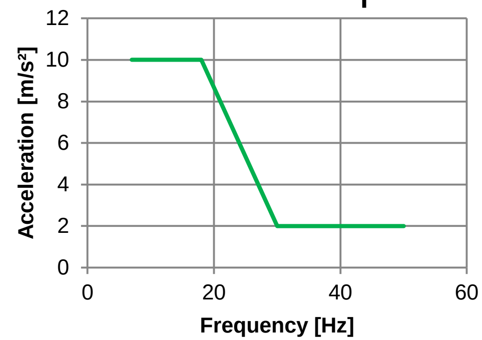
Noise



ECE R100



Sinus sweep

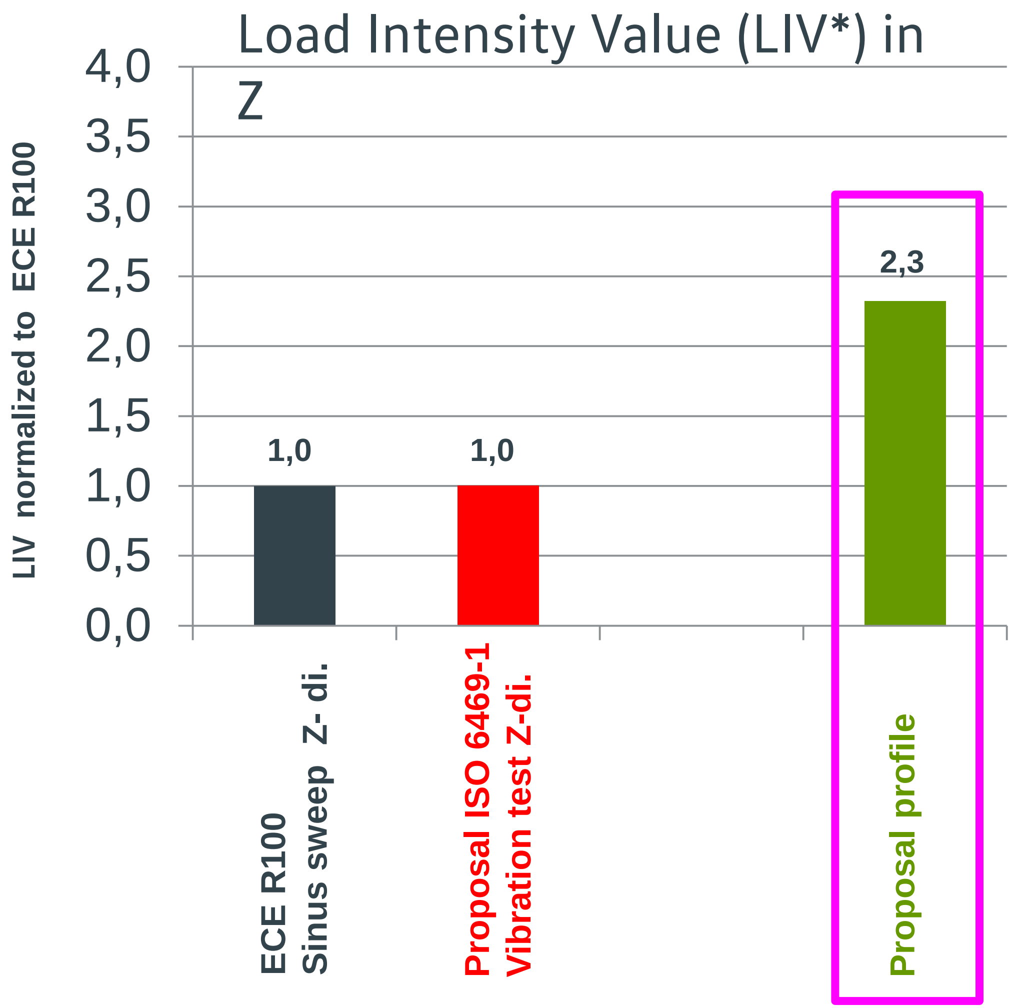


Direction: Z, X, Y

Direction: Z

Vibration requirements in GTR 20: Justification 3

Comparison of the mechanical stress of ECE R100 and new profile



* **LIV**
= Sum of the weighted load amplitudes

ECE R100 does not consider x- and y-directions

Vibration requirements in GTR 20: Justification 4

Considerations on vibration profile

Sinus profiles (sweeps) generally apply to the testing of parts fitted to the internal combustion engine. This is not applicable to REESS.

Noise profiles apply to components, which are stimulated by road surfaces. Using random profiles is appropriate for REESS.

The shape of the proposed random profile is derived from vehicle measurements.

The proposed random profile has the same load intensity (LIV) in the dominant direction (Z-direction) as the sinus profile of ECE R100.

The extension of three spatial directions takes into account the actual mechanical load situation in the vehicle.

Annex: Explanation of LIVs (1)

Method for calculation of LIV

The calculation of LIV (Load Intensity Value) is a method to compare relatively the fatigue damage of two load signals (e.g. force, torque, bending moment, acceleration). LIV shall be calculated as follows:

1. Measurement of the load

    Measurement of the load A (e.g. DUT in a vehicle on a test track)

    Measurement of the load B (e.g. DUT on the test bench)

2. Calculation of the load distribution from Range Pair Counting (RPC) according to ASTM Standard E 1049-85 „Standard Practices for Cycle Counting in Fatigue Analysis “

    Distribution of load A

    Distribution of load B

Annex: Explanation of LIVs (2)

3. The calculated total fatigue damage is determined by the addition of all partial damages. Partial damages are calculated for each load cycle using the Palmgren-Miner rule with the modification “elementary”. The slope k of the associated s-n-curve is 5.

   a. For the partial damage for one load cycle the following formula applies:

   $d_i = 1 / N_i$

   b. For the total fatigue damage D with all (l) load horizons and the step frequency h_i of the vibration signal the following formula applies:

   $D = \sum_{i=1}^{l} \frac{h_i}{N_i}$

4. For the calculation of LIV the following formula is used:

   $LIV = D_{\text{load A}} / D_{\text{load B}}$