# EVS vibration ad-hoc meeting report

2021.10

# EVS vibration ad-hoc meeting report

- Date:Sep 29th,2021
- Participants:China, Japan, JRC, OICA
- Contents:
  - China introduced proposed draft on vibration test;
  - OICA and JRC introduced their opinions on vibration test.
- Discussion：
  - The necessity of vibration test:
    - a)safety test or reliability test?
    - b)whether the addition of vibration test is benefitial for battery satey.
  - Vehicle vibration profile:
    - a)how the China’s profile is made ;
    - b)adaptive for all kinds of electric vehicle;
    - c)comparison with other profile, such as ISO 6469-1, ISO 19453-6, ISO 16750-3 and IEC 60048.

# Outline

- Is the vibration test a safety test or reliability test?
- How the China’s vibration profile is made?
- Adaptive of the vibration profile for all kinds of electric vehicle.
- Comparison with other profile, such as ISO 6469-1, ISO 19453-6.

# Is the vibration test a safety test or reliability test?

## Example analysis of EV battery

**Presented at EVS GTR 17th 2019.01**

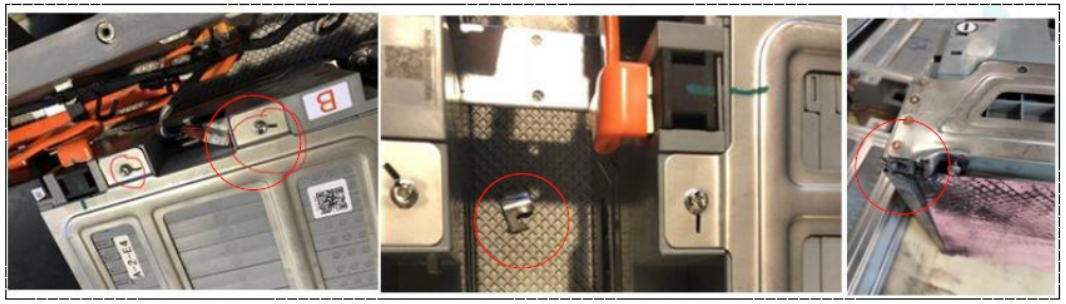
- **The GTR vibration cannot cover all vibration load in reality**

**■Test result:**

➢Passed the EVS-GTR but failed in the road spectrum test

Vibration test photo

Pass the EVS-GTR

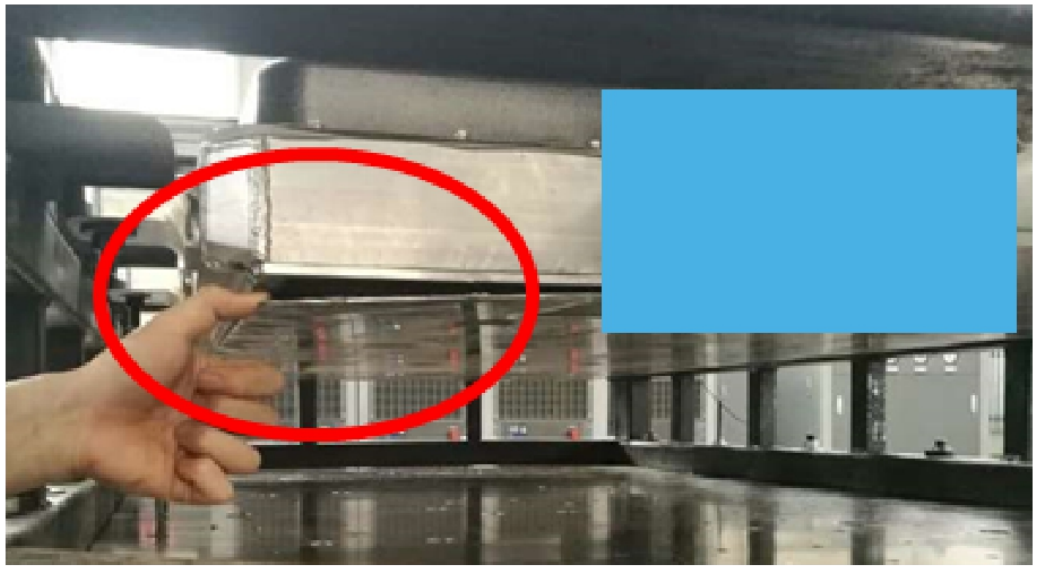


Screw loose， Cracking of conductive metal parts and structural parts

Fail in the road spectrum test

# Is the vibration test a safety test or reliability test?

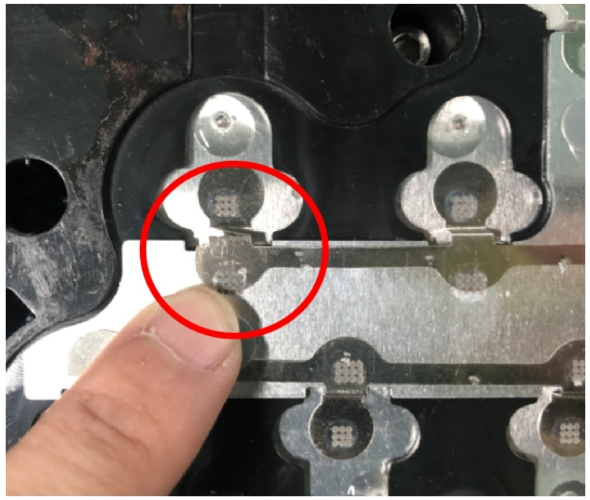
## Vibration leads to battery pack shell damage



- Vibration leads to shell damage and IP protection failure.

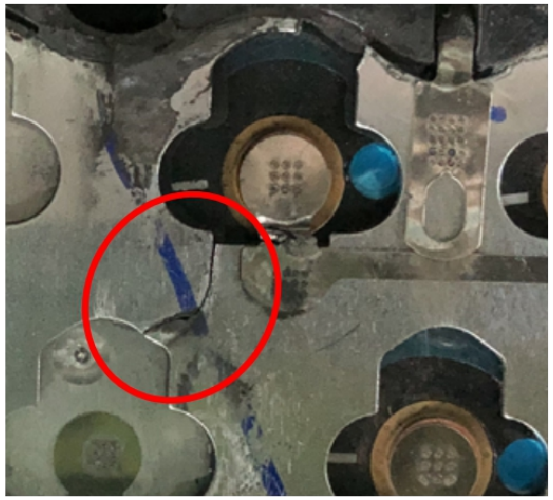
# Is the vibration test a safety test or reliability test?

## Vibration leads to fracture of electrode collector and BUSBAR

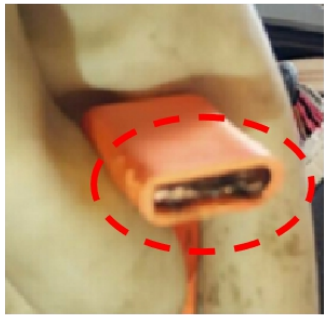


- Vibration leads to the breakage of the electrode connector of the cell, which may lead to:

a) Overcharge and overdischarge (for example serial first and then parallel connected modules);
b) Overheating due to increased local resistance;
c) Disconnection with current leads to ignition.



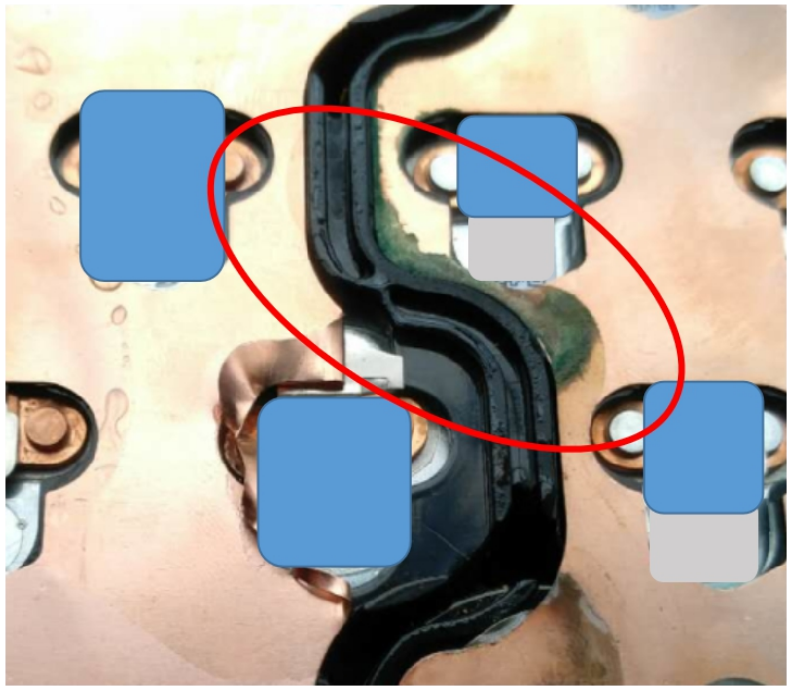
- Local damage of busbar may lead to excessive current in some areas, and then cause overheating. Overheating may cause thermal runaway.



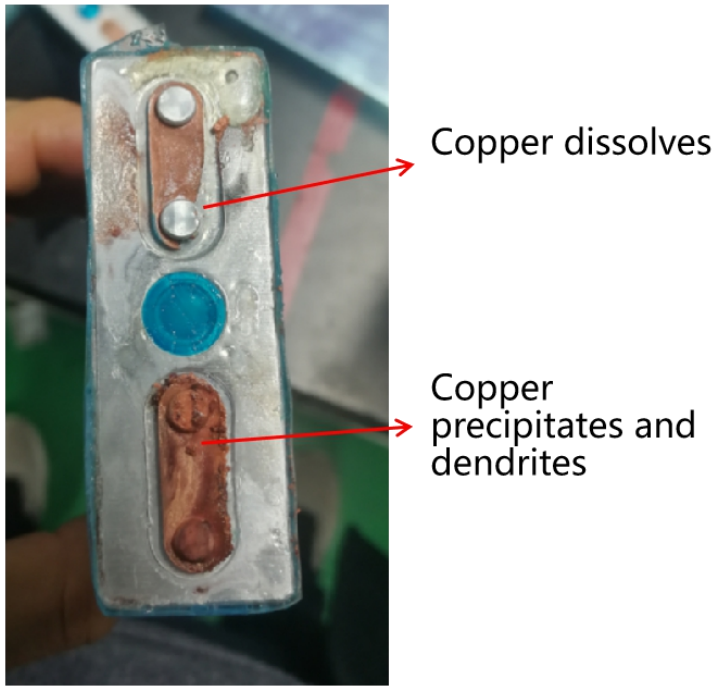
- The high voltage connecting wire inside the battery pack is broken, causing open circuit or sparking.
- After the bus bar is broken, the section is burnt.

# Is the vibration test a safety test or reliability test?

**Vibration leads to electrolyte leakage**



- Vibration leads to electrolyte leakage, leakage leads to copper precipitation, and copper precipitation leads to short circuit.




- Leakage of electrolyte leads to external short circuit, and copper in one side of the collector dissolves and precipitates on the other side

# Is the vibration test a safety test or reliability test?

## Vibration leads to electrolyte leakage

- Screw of the relay is loose, causing ignition and ablation.
- Other loose of electrical connections may also cause over heating, which may cause the surrounding battery cells to be heated and lead to thermal runaway.

# Is the vibration test a safety test or reliability test?

- **Vibration may lead to mechanical structure, electrical connection, electrical protection and many other aspects of failure, these failures will lead to battery safety accidents**.

  - Damage of the battery pack shell/case
  - Busbar fracture
  - Collector tearing
  - Loose of bolts and connections
  - Leakage of water cooling plate interface
  - Battery electrolyte leakage
  - ……

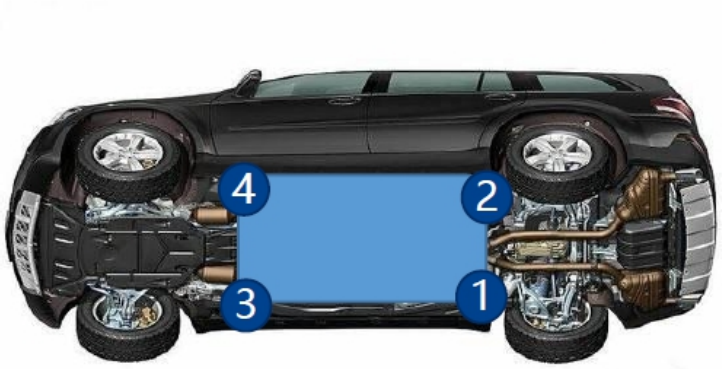
# Outline

- Is the vibration test a safety test or reliability test?
- How the China’s vibration profile is made?
- Adaptive of the vibration profile for all kinds of electric vehicle.
- Comparison with other profile, such as ISO 6469-1, ISO 19453-6.

# How the China's vibration profile is made?

- **Sensor layout principle: focus on the installation of fixed parts fixed position**
- **At least 4 sensors are fixed distributed at different installation points**

| N.O. | Position | Vehicle Direction | Sensor direction | Channels |
|---|---|---|---|---|
| 2601 | Right rear | X | X | AI-0 |
| | | Y | Z | AI-1 |
| | | Z | Y | AI-2 |
| 2602 | Left rear | X | X | AI-3 |
| | | Y | Z | AI-4 |
| | | Z | Y | AI-5 |
| 2603 | Right forward | X | X | AI-6 |
| | | Y | Y | AI-7 |
| | | Z | Z | AI-8 |
| 2604 | Left forward | X | X | AI-9 |
| | | Y | Y | AI-10 |
| | | Z | Z | AI-11 |



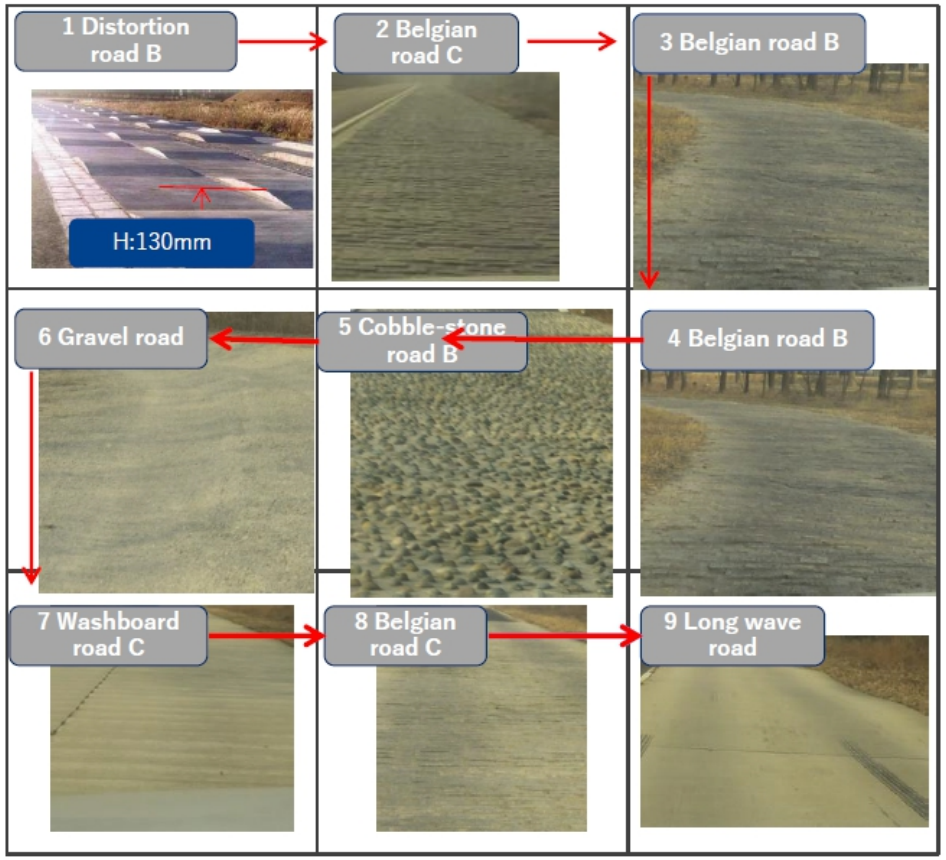

Source: EVS19-E3VP-0100 [CN]Review of the concept, test data and derivation procedures of China proposal

# How the China's vibration profile is made?

■ Rough roads and test procedure

For passenger car

| Seq. | Rough roads | length (m) | % | Vehicle speed (km/h) | Test times |
|---|---|---|---|---|---|
| 1 | Twisting road B | 85 | 2.02% | 10 | 3 |
| 2 | Belgian road C | 300 | 7.14% | 40 | |
| 3 | Belgian road B | 989 | 23.53% | 50 | |
| 4 | Belgian road B | 989 | 23.53% | 50 | |
| 5 | Cobble-stone road B | 335 | 7.97% | 50 | |
| 6 | Gravel road | 815 | 19.39% | 40 | |
| 7 | Washboard Road C | 300 | 7.14% | 50 | |
| 8 | Belgian road C | 300 | 7.14% | 50 | |
| 9 | Long wave road | 90 | 2.14% | 50 | |




① Data acquisation
- Driving conditions
- Measurement position

② Data analysis
- Data extraction
- Frequency domain analysis

③ Data normalization
- Set mileage life
- Set aging factor
- Normalization
- PSD for 21 hours

④ Formulate bench vibration conditions
- PSD and RMS for test

Source: EVS19-E3VP-0100 [CN]Review of the concept, test data and derivation procedures of China proposal

# Outline

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- Adaptive of the vibration profile for all kinds of electric vehicle.
- Comparison with other profile, such as ISO 6469-1, ISO 19453-6.

# Adaptive of the vibration profile for all kinds of electric vehicle.

**M1 N1 group:**
**2 mini cars，3 cargo vans，11 passenger cars, including EV, PHEV and HEV.**
**Wheelbase from 1765mm to 3850mm**






| Type | | Wheelbase（mm） | pack location |
|---|---|---|---|
| mini car | EV | 1765 | bottom |
| mini car | EV | 2150 | bottom |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| cargo van | | | |
| passenger car | | | |
| passenger car | | | |
| passenger car | | | |
| cargo van | | | |
| cargo van | | | |

**Bus group:**
**7 buses, including EV, PHEV and FCEV.**


| Type | | Length（mm） | Pack location |
|---|---|---|---|
| bus | EV | 12000 | bottom & back |
| bus | EV | 12000 | top |
| bus | PHEV | 10500 | top |
| bus | PHEV | 8545 | Engine compartment |
| bus | EV | 8010 | bottom |
| bus | EV | 10480 | bottom |
| bus | FCEV | 12000 | bottom |

Source: EVS19-E3VP-0100 [CN]Review of the concept, test data and derivation procedures of China proposal

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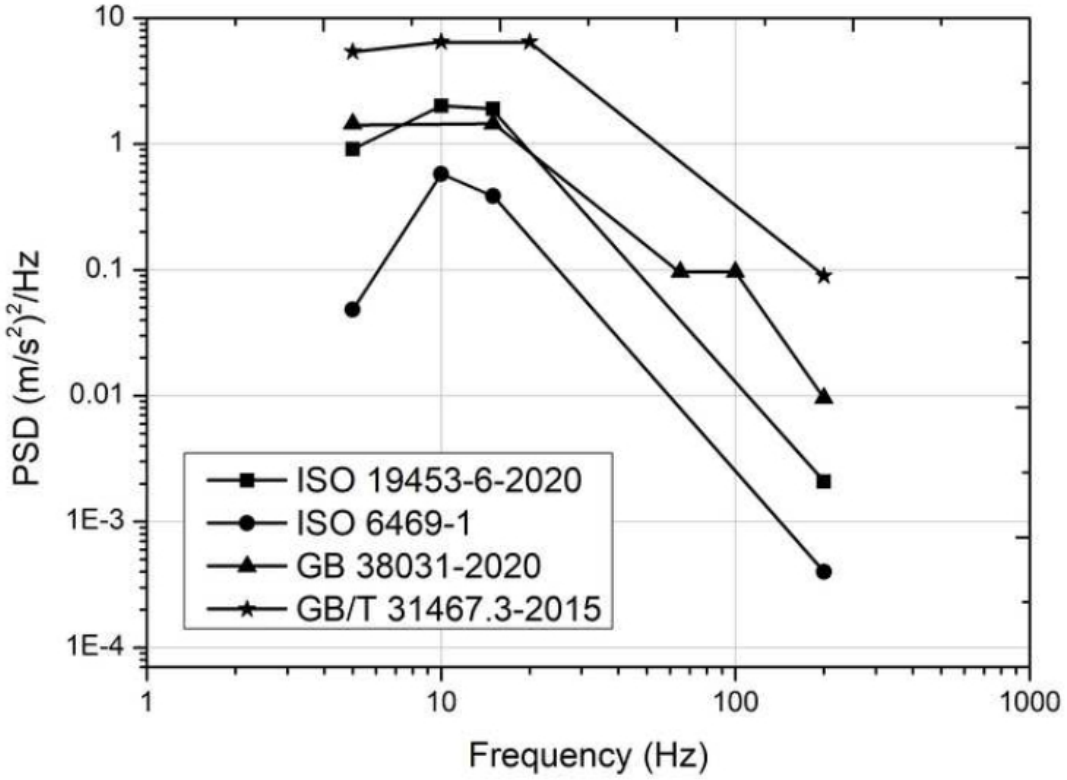
# Comparison with other profile, such as ISO 6469-1, ISO 19453-6.




The required Spectral Power Densities (PSD) in Zdirection of the random vibration patterns for the vehicle types M1 and N1 of the Chinese standards GB 38031 and GB/T 31467.3 as well as the standards ISO 6469-1 and ISO 19453-6. The PSD is used to normalize the random vibration signals at different frequency resolutions and therefore random vibration data can be compared independently of the frequency resolution.

The left figure shows that PSDs in the four standards are all in the frequency range from 5 to 200 Hz and share a similar curve over the frequency. In terms of spectral power density, GB/T 31467.3-2015 is highest, followed by GB 38031, ISO 19453-6and ISO 6469-1. As in GB 38031, the PSD curve in ISO 19453-6 is derived from actual test data. However, regarding the magnitude of the vibration load, ISO 6469 does not use actual vehicle data, but the vibration load of ECE R100.

it is recommended to adapt the random vibration approach based on real vehicle data of the latest electric vehicles, specific road conditions and individual, country-specific driving styles

# THANKS