



Rechargeable Energy Storage System (RESS) Charging Noise Evaluation Procedure

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. Define the process of quantifying vehicle level exterior noise from components/systems operating at any charging condition.

1.2 Applicability. This procedure applies to vehicle tests for all electric and hybrid vehicles that operate in a charging condition.

1.3 Remarks. This procedure is a guideline for measuring the noise emission of auxiliary systems running during a charging event, such as electric cooling pumps, electric Air Conditioning (AC) compressors, or Condenser Radiator Fan Modules (CRFM).

The noise from the auxiliary systems shall not be noticed as disturbing outside the vehicle inside any residence.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ANSI 3.5 IEC 651

2.2 GM Standards/Specifications.

None

2.3 Additional References.

Siemens LMS software available at <https://www.plm.automation.siemens.com/en/products/lms/>
Vehicle Technical Specification (VTS)

3 Resources

3.1 Facilities. All measurements shall be performed in a hemi-anechoic test room with environmental capability free from interfering noises or outdoors in a free-field area if appropriate temperatures can be maintained.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Microphones. Six (6) free-field microphones are preferred for vehicle exterior measurement locations. Pressure microphones may be used at the exterior locations if free-field microphones are not available. Optional interior microphones may be used. Two (2) random incidence microphones are preferred for vehicle interior locations. Free-field microphones may be used for interior locations if random incidence microphones are not available. All devices shall meet Class 1 accuracy corresponding to IEC 651 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

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3.2.2 Data Acquisition System (DAS). Multi-channel data acquisition hardware capable of calculating frequency domain results between 22 Hz and 11 200 Hz with a minimum of 80 dB dynamic range. This hardware shall meet Class 1 accuracy corresponding to IEC 651 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

3.3 Test Vehicle/Test Piece. The tests shall be performed on a vehicle which represents the current part release status. Deviations (e.g., obvious faults) shall be eliminated or recorded.

3.4 Test Time.

Calendar time: 1.5 days

Test time: 4 hours

Coordination time: 16 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. To complete this test, one engineer or qualified technician with knowledge of noise and vibration data acquisition, analysis, equipment usage, and test setup is required.

4 Procedure

4.1 Preparation. Check the vehicle according to 3.3.

4.2 Conditions.

4.2.1 Environmental Conditions. The test shall be performed with the ambient air temperature ($20\text{ }^{\circ}\text{C} \pm 4\text{ }^{\circ}\text{C}$) and at high ambient temperature ($> 35\text{ }^{\circ}\text{C}$).

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Calibration Verification. Check equipment for valid calibration date. Replace out of date equipment. Perform microphone calibration verification per ANSI 3.5.

4.3.2 Install Data Acquisition Equipment (see 7.2 for M_{GX} Location Key). Set up exterior microphones as specified in Appendix B, Figures B1 and B2 for global exterior microphone locations M_{G1} , M_{G2} , M_{G3} , M_{G8} , M_{G9} , and M_{G10} as needed to capture noise sources. If there are no sources running in the rear of the vehicle during the charging event, then M_{G8} thru M_{G10} may be deleted. Position all microphones at a distance of 1.6 m from the floor in the vertical direction and 1.0 m from the vehicle. Microphones M_{G2} , and M_{G3} shall be positioned in line with the center of the front wheels of the vehicle. Position microphones M_{G8} and M_{G9} in line with the center of the rear wheels of the vehicle. Locate microphones M_{G1} and M_{G10} on the front and rear center line of the vehicle. Orient all exterior microphones so that they are directed towards the vehicle parallel to the floor.

Optional: Install interior microphones in positions as specified in Appendix A, Figures A1 and A2. Standard microphone positions for left hand drive (LHD) vehicles are left front seat right ear (LFRE) and the right rear seat (RR) with an optional right front seat left ear (RFLE) position. Standard positions for right hand drive vehicles are RFLE and left rear seat (LR) with an optional LFRE position. Seats should be positioned as specified in Appendix C.

4.3.3 Vehicle Setup. The vehicle may need to be driven prior to data acquisition to ensure the energy storage system (ESS) is fully discharged.

The vehicle should be unloaded, except for test equipment as required. Adjust seats and headrests according to Appendix C if optional interior measurements will be conducted.

Let the vehicle stabilize at ambient temperature (approximately $22\text{ }^{\circ}\text{C}$) for initial data acquisition.

4.3.3.1 For Use When Optional Interior Microphones Are Used. Close all doors, windows, sliding roof, sunroof and sunscreen. Roll up sun shields and roller load compartment shields.

Turn off the radio and other electronic devices. Heating, ventilation and air conditioning (HVAC) blower shall be off during all measurements. The fan noise for the ESS shall be minimized as to not influence the auxiliary system noise measurement.

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4.3.4 Data Acquisition. Check vehicle settings per 4.3.3.

For ambient temperature charging noise: Plug in the vehicle for charging and acquire data. Unplug the power cord when data acquisition is complete. Repeat sequence two (2) more times, for a total of three (3) data points.

For high temperature charging noise: Soak the vehicle at high ambient temperature ($> 35^{\circ}\text{C}$) for at least 16 h. Do not move the vehicle during or after the soak until all subsequent data acquisition has been completed.

Plug in the vehicle for charging and acquire data. Unplug the power cord immediately after data acquisition is complete. Repeat the measurement sequence in this section for several cycles of plug-in/unplug until the internal battery temperature has stabilized.

4.3.4.1 Steady State Data Acquisition. Set up DAS to acquire A-weighted sound pressure level data capable of providing steady state narrow-band data using the following parameters:

- Frequency Range: 22 Hz to 11 200 Hz
- Frequency Resolution: 1 Hz
- Window: Hanning
- Energy Averaging: 50 Averages, 50% Overlap

4.3.4.1.1 (Optional) Steady State Data Acquisition with MAP Statistics (see 7.1).

- Time sufficient to capture the component operation (minimum 30 s)
- Increment 0.5 s

Acquire adequate data to allow processing in $\frac{1}{3}$ octave and narrowband spectral formats. A single acquisition for both analysis formats is preferred.

Track cooling fan speed and percent duty cycle, compressor rpm and percent duty cycle, and battery temperatures.

Store data as required for acquisition system.

5 Data

5.1 Calculations. Process noise data as the following paragraphs define.

5.1.1 Steady-State Data. Process data to calculate overall sound pressure level in dB(A) relative to 20 μPa and $\frac{1}{3}$ octave band levels using ANSI 3.5 specified filters for the 25 Hz to 10 000 Hz frequency bands.

5.1.1.1 (Optional) Time tracked Data Processing.

For sound pressure: Process data to obtain peak and average amplitudes (decibels (dB)) as a function of frequency (modified overall level) using Frequency sections with a band pass starting at the lower level of the meaningful acoustic noise for the hemi-anechoic test room up to 11 200 Hz and $\frac{1}{3}$ octave band levels in the 22 Hz to 11 200 Hz frequency range.

Optional Use of MAP Statistics on Individual and Grouped Channels. The exterior microphones (M_{G1} , M_{G2} , M_{G3} , M_{G8} , M_{G9} , and M_{G10}), interior microphones (LF, RR, etc.) are grouped for derived channels maximum calculations for each group. MAP statistics is used for spectrum peak hold and spectrum.

5.2 Interpretation of Results. Compare the narrow-band and $\frac{1}{3}$ octave sound pressure levels from each microphone to the Vehicle Technical Specification (VTS) target levels. The sound pressure levels must meet the target levels for each microphone location.

5.3 Test Documentation. Standardized formats contained in the Global VTS template shall be used to view data.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

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