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Limits and Measurement Methods for Bus Interior Noise

客车车内噪声限值及测量方法

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Limits and Measurement Methods for Bus Interior Noise

1 Scope

This document specifies the limits, measurement instruments, measurement conditions, vehicle conditions, measurement methods and test reports for bus interior noise.

This document applies to Category-M₂ and Category-M₃ vehicles.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 3241-2010 Electroacoustics - Octave-band and Fractional-octave-band Filters

GB/T 3730.1 Terms and Definitions of Motor Vehicles, Trailers and Combination Vehicle - Part 1: Types

GB/T 3785.1-2023 Electroacoustics - Sound Level Meters - Part 1: Specifications

GB/T 3947 Acoustical Terminology

GB/T 8170 Rules of Rounding off for Numerical Values & Expression and Judgement of Limiting Values

GB/T 15089 Classification of Power-driven Vehicle and Trailers

GB/T 15173-2010 Electroacoustics - Sound Calibrators

GB/T 19596 Terminology of Electric Vehicles

3 Terms and Definitions

The terms and definitions defined in GB/T 3730.1, GB/T 3947, GB/T 15089 and GB/T 19596, and the following terms and definitions are applicable to this document.

3.1 steady noise

During steady operation, continuous noise generated by a mixture of tire noise, airflow noise, vehicle body vibration noise, powertrain, transmission system, or component operating noise.

3.2 background noise

Noise emitted by all noise sources other than the noise source being measured.

NOTE: background noise includes airborne sound, noise from structural vibration and electrical noise in the instrument.

3.3 loudness

The property of the auditory sense that determines the intensity of a sound.

NOTE: loudness depends primarily on the sound pressure that triggers the auditory sense, but it is also related to the frequency and waveform of the sound. The unit is sone.

[source: GB/T 3947-1996, 9.7, modified]

3.4 sharpness

An auditory sensation that describes the sharpness or harshness of a sound's timbre.

NOTE: sharpness is a psychological indicator that measures the amount of high-frequency components in a sound that reflects the ratio of high-frequency energy to the total energy in the sound. The unit is acum. 1 acum is the sharpness produced by a 60 dB narrowband noise with a center frequency of 1 kHz and a bandwidth of 160 Hz.

3.5 state of charge; SOC

The percentage of the capacity that can be released in the current battery under specified discharge conditions in relation to the available capacity.

[source: GB/T 19596-2017, 3.3.3.2.5]

4 Noise Limits

4.1 The sound pressure level and loudness of interior noise of internal combustion engine buses and hybrid electric buses shall not exceed the limits specified in Table 1.

4.2 The sound pressure level, loudness and sharpness of interior noise of pure electric buses and buses with pure electric mode shall not exceed the limits specified in Table 2.

5 Measurement Instruments

5.1 Acoustic Measurement Instruments

5.1.1 The sound level meter or other equivalent measurement equipment used for measurement shall meet the requirements for Class 1 sound level meter as specified in GB/T 3785.1-2023. Measurements shall use the “A” frequency weighting characteristic and the “F” time weighting characteristic. If the sound level meter or other equivalent measurement equipment is capable of automatically sampling and measuring the A-weighted sound level, then, the time interval of reading shall not exceed 30 ms. The microphone shall be an omnidirectional microphone.

5.1.2 The loudness and sharpness measurement system shall meet the relevant requirements for Class 1 filters in GB/T 3241-2010. The measurement equipment shall be capable of at least 24-bit quantization. The sampling rate, measuring range and dynamic range of the equipment shall be appropriate for the signal being measured.

5.1.3 Before and after measurement, the entire measurement equipment shall be calibrated using an acoustic calibrator with Class 1 accuracy and meeting the provisions of GB/T 15173-2010. Without further adjustments, if the difference between the last calibration reading and the previous calibration reading exceeds 0.5 dB(A), then, the measurement result after the previous calibration is considered invalid.

5.2 Engine Speed and Vehicle Speed Measurement Instruments

An engine speed measurement instrument with an accuracy of at least $\pm 2\%$ shall be used for speed measurement, and a vehicle speed measurement instrument with an accuracy of at least $\pm 1\%$ shall be used for vehicle speed measurement. Data from the bus's own speedometer, tachometer, on-board diagnostics (OBD), or similar systems shall not be used.

6 Measurement Conditions

6.1 The measurement location shall meet the following conditions: noise radiated from the bus can only become part of the interior noise through reflection from the road surface and cannot become part of the interior noise through reflection from buildings, walls, or other objects. During measurement, the distance between the bus and other objects shall be greater than 50 m.

6.2 The test section shall be a clean, dry, flat, unfrozen asphalt or concrete pavement with no joints, uneven surfaces, or similar surface structures. The test route in the test section shall be straight.

6.3 The wind speed at a height of (1.2 ± 0.05) m along the measurement route shall not exceed 5 m/s. The temperature range shall be $5\text{ }^{\circ}\text{C} \sim 40\text{ }^{\circ}\text{C}$.

6.4 The measured noise shall be 10 dB(A) higher than the background noise. When the measured noise differs from the background noise by 10 dB(A) $\sim$ 15 dB(A), the corresponding correction value in Table 3 shall be subtracted from the measurement equipment reading to obtain the measurement result.

7 Vehicle Conditions

7.1 Powertrain

7.1.1 Before measurement, all powertrain operating conditions, such as fuel, lubricating oil, ignition timing or injection time, shall comply with the manufacturer's specifications. The powertrain shall be stable within the normal operating temperature range, and the powertrain cooling system shall be normally functioning.

7.1.2 Before measurement, the technical condition of the vehicle under test shall meet the technical conditions of the vehicle model, with particular attention paid to its acceleration performance and maximum vehicle speed.

7.1.3 Before test, the state of charge (SOC) of the power battery of pure electric buses shall be no less than 60%. The SOC of the power battery of fuel cell buses or hybrid buses shall be within the normal range specified by the bus manufacturer.

7.2 Tires

7.2.1 The tires used on the vehicle under test shall conform to the model specified by the manufacturing enterprise, and the tire inflation pressure shall comply with the manufacturing enterprise's specifications.

7.2.2 The tread depth of the steering wheel shall be no less than 3.2 mm, and the tread depth of all other tires shall be no less than 1.6 mm.

7.2.3 Tire model and inflation pressure shall be recorded in the test report.

7.3 Vehicle Mass Status

The vehicle shall be unloaded during the noise test. No other loads shall be present except for the driver, necessary measurement personnel and test equipment.

7.4 Sunroofs, Windows, Air Inlets (outlets), Auxiliary Devices and Adjustable Seats

7.4.1 All sunroofs, windows and cover plates shall be closed; for vehicles with closable air inlets and outlets, they shall all be closed.

7.4.2 Auxiliary devices, such as the air compressor, windshield wipers, heater, fan, air conditioner, low-speed warning sound device and interior audio system shall not operate during the measurement and test. If a certain auxiliary device automatically operates and has a significant impact on the bus interior noise, it shall remain in automatic operation throughout the measurement period, and the operating conditions shall be stated in the test report.

8 Measurement Method

8.1 Selection of Measurement Points

8.1.1 The measurement point of the driver zone shall be located at the driver's right ear.

8.1.2 For city buses, measurement points shall be located in the passenger zone in accordance with the vehicle's interior dimensions. Measurements shall be respectively conducted at three points (front, middle and rear) along the vehicle's longitudinal centerline. The front measurement point shall be located at the frontmost position of the passenger zone, the middle measurement point shall be located in the middle of the passenger zone, and the rear measurement point shall be located on the left side (facing the vehicle's direction of travel) of the seat close to the longitudinal centerline. The driver zone shall not be included in the calculation of the passenger zone's interior dimensions. For articulated buses, the middle measurement point is located above the rear axle floor of the front compartment; for double-decker city buses, only the lower deck passenger zone shall be measured.

8.1.3 For other buses, one measurement point shall be located in each of the front, middle and rear rows of seats in the passenger zone. The measurement point shall be located along the longitudinal centerline of the vehicle, at the first seat position on the left side (facing the vehicle's direction of travel) of the front, middle and rearmost rows. Measurement points shall not be located on the vehicle's axis. When calculating the number of rows in a bus, the left side is used as the reference, excluding the seat in the driver zone. When the number of seating rows (n) is even, for buses with rear powertrains, the middle row is row $(n/2 + 1)$; for buses with front powertrains, the middle row is row $(n/2 - 1)$.

8.1.4 Measurement points are shown in Figure A.1 and Figure A.2 of Appendix A. During the test, no one shall be seated in the selected measurement positions, except for the driver's position.

8.2 Microphone Placement

8.2.1 The vertical coordinate of the microphone placement position in the driver zone shall be set at (0.70 ± 0.10) m above the intersection of the seat surface and the backrest surface. The horizontal placement position shall be (0.20 ± 0.02) m to the right of the center plane of the seat, as shown in Figure A.3. Adjustable seats shall be adjusted in accordance with 7.4.3.

8.2.2 The vertical coordinate of the microphone placement position in the passenger zone shall be set at (0.70 ± 0.05) m above the intersection of the seat surface and the backrest surface. The horizontal placement position shall be (0.20 ± 0.02) m to the right of the center plane of the seat, as shown in Figure A.4.

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Contact: Wayne Zheng, Sales@ChineseStandard.net

Linkin: <https://www.linkedin.com/in/waynezhengwenrui/>

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