



Wind Noise Test 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. Vehicle measurement of interior wind noise, exterior wind noise, and buffeting noise, in a wind tunnel at constant wind conditions.

1.2 Applicability. Applies to all vehicles or appropriate full-scale models (clay, glass fiber, etc.) Allowable weight and dimensions depend on the particular wind tunnel (e.g., General Motors Aerodynamic Laboratory 4500 kg; Full Scale Wind Tunnel of the University of Stuttgart 6000 kg, 6 m length; Monash University Vehicle Aero Acoustics Laboratories 4000 kg, 6 m length; Royal Melbourne Institute of Technology 3000 kg).

1.3 Remarks. This test procedure has been laid out for compatibility to corresponding procedures within the GM organization. It replaces all regional wind tunnel related wind noise test procedures and is the basis for comparability of measurements within the worldwide GM organization.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Cafeo, John A. Interior Vehicle Wind Noise: Description, Quantification and Measurement Using Single Number Descriptors, PG51439, Oct. 9, 1987.
- GM Wind Noise Web Page; <https://gmweb.gm.com/engineering/GNVC/Pages/WindNoise.aspx>
The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.
- Vehicle Technical Specification (VTS) 3.2.1.3.8.3.1

3 Resources

3.1 Facilities. Full scale automotive wind tunnel (preferably aero acoustic).

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 Interior Wind Noise Measurements.

- Four (4) microphones; Brüel & Kjaer ½ in Type 4943, (or equivalent pressure/diffuse field type microphones).
- Four (4) microphone stands.
- Four (4) microphone preamplifiers; Brüel & Kjaer type 2669 (or equivalent).

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- One (1) microphone calibrator; Brüel & Kjaer type 4231 (or equivalent).
- One (1) data acquisition hardware system; LMS Model No. PS12-2 MOB front end, or Headlab labM6 No. 3724 (or equivalent).
- One (1) data analysis software system; LMS Test.Lab (or equivalent).
- One (1) wind noise data index and plotting software program; WindPlotter, GWICAS (or equivalent).
- One (1) test run log.

3.2.2 Exterior Wind Noise Measurements (Sound Intensity).

- One (1) sound intensity measurement probe, consisting of two (2) parallel aligned microphones equipped with nose cones, the distance between the microphones shall be suited to measure the frequency range of at least 0.5 kHz to 5 kHz.
- Two (2) microphones; Brüel & Kjaer ½ in Type 4943, (or equivalent pressure/diffuse field type mics).
- Two (2) microphone preamplifiers; Brüel & Kjaer type 2669 (or equivalent).
- Two (2) microphone nose cones; Brüel & Kjaer ½ in Type UA-0386 (or equivalent).
- One (1) microphone calibrator Brüel & Kjaer type 4231 (or equivalent).
- One (1) data acquisition hardware system; LMS Model No. PS12-2 MOB front end, or Brüel & Kjaer 3050-A (or equivalent).
- One (1) data analysis software system; LMS Test.Lab (or equivalent).
- One (1) wind noise data index and plotting software program; WindPlotter, GWICAS (or equivalent).
- Intensity probe stands or adapter to wind tunnel traversing gear system.
- One (1) test run log.

3.2.3 Open Glass Buffeting Noise.

- Equipment as specified in 3.2.1
- Four (4) foam windscreens; Brüel & Kjaer UA-0237 (or equivalent).

3.3 Test Vehicle/Test Piece. Test objects can be production, non-saleable vehicles, prototypes or appropriate full-scale models. The equipment of the vehicle shall be representative for the test purpose (vehicles off the production line) and/or verified to have proper design intent content (prototypes or non-saleable vehicles).

3.4 Test Time.

Calendar time: 1 d to 2 d (typical)
Test hours: 4 h to 20 h (typical)
Coordination hours: 8 h

3.5 Test Required Information. All information regarding specific test purposes such as component drawings, sample descriptions, etc., shall be available prior to testing.

3.6 Personnel/Skills. Required personnel depends on the wind tunnel. Typical numbers are (minimum requirement):

3.6.1 GMAL. General Motors Aerodynamic Laboratory, GM Tech Center, Warren, Michigan, USA: 1 engineer.

3.6.2 FKFS. Full Scale Wind Tunnel of the University of Stuttgart, Stuttgart-Vaihingen, Germany: 1 engineer.

3.6.3 Monash. Monash University Wind Tunnel Facility, Melbourne, Australia: 1 engineer, 2 technicians.

3.6.4 Tongji. Tongji University Aeroacoustic Wind Tunnel, Shanghai, China: 1 engineer, 1 technician.

3.6.5 DTF. Wind Tunnel 8, Ford - Driveability Test Facility, Allen Park, Michigan, USA: 1 engineer, 1 technician.

3.6.6 Lockheed. Lockheed Martin Low Speed Wind Tunnel, Marietta, Georgia, USA: 1 engineer, 1 technician.

Additional personnel supplied by the wind tunnel are required to operate the wind tunnel and, depending on the particular tunnel, the measurement equipment.

Personnel perform an on-site analysis of the data, decide on test configurations, and keep the test schedule and a detailed run-log. Personnel should be proficient in acoustic measurement techniques, signal processing

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practices and computer data acquisitions. At least one person shall have extensive experience with wind noise measurements.

4 Procedure

4.1 Preparation.

4.1.1 Interior Wind Noise Measurements.

4.1.1.1 Interior Treatment. Shut off heating, ventilating and air conditioning (HVAC) system and place it in recirculation mode. Shut off radio. Confirm that all windows are closed. For power windows, completely cycle moveable windows to ensure they are closed (with engine running). All HVAC vents, including instrument panel defroster vents, shall be closed and taped over. All seals (door to body, side glass to door) shall be taped over to eliminate any leaks. Permagum/thumbgrade sealer (Ø 13 mm) is used to cover the taped seals in order to increase sound transmission loss (STL) characteristics.

4.1.1.2 Exterior Treatment. All appropriate exterior surface interfaces and discontinuities shall be taped (door cuts, glass seals, belt moldings, drip rails, windshield and backlight moldings, outside rear view mirror cut lines and cavities, door handles, etc.)

4.1.1.3 Foam Separation. Foam separation (convoluted polyurethane foam, 150 mm minimum thick) for the vehicle interior shall be cut to separate the vehicle into quadrants. The foam termination pieces shall fit snug to the limiting contour of the interior surfaces to achieve acoustically independent areas. If necessary, remove the interior mirror.

A piece of convoluted foam shall be placed on each seat cushion around the microphone stand, extending from the seat back to the dash for the front seats, and to the front seat backs for the rear seats. The seat foam pieces extend to the door trim panel to complete the foam termination for each vehicle quadrant.

4.1.1.4 Vehicle Access Door. Access to the Four (4) door or Five (5) door vehicles is generally provided through the rear door opposite driver's door by leaving the rear door primary sealing untreated. In the case of two (2) door vehicles, the primary sealing of the passenger door shall be untreated. In case of a Three (3) door vehicle with foldable rear seats, the hatch door can be used as an access door.

4.1.2 Exterior Wind Noise Measurements (Sound Intensity).

4.1.2.1 Exterior Treatment. All appropriate exterior surface interfaces and discontinuities near the component to be evaluated shall be taped.

4.1.2.2 Interior Treatment. The interior of the vehicle does not need to be treated for exterior wind noise measurements. In the case that interior measurements and exterior measurements shall be conducted in parallel, the vehicle needs to be treated as described in 4.1.1.

4.1.3 Open Glass Buffeting Noise Measurements.

4.1.3.1 Exterior Treatment. None required unless an exterior item is creating interior wind noise such that the program intended wind noise level is exceeded significantly (usually Vehicle Technical Specification (VTS) "Isolated Wind Noise" level plus 5 dB due to lack of interior convoluted foam).

4.1.3.2 Interior Treatment. The interior should not be treated to allow proper pressurization of the vehicle. Interior seals would be treated only if found to be deficient to meet the VTS target (see 4.1.3.1). No foam separation is used.

4.2 Conditions.

4.2.1 Environmental Conditions. Air temperature, barometric pressure and (optionally) the vehicle frontal area are used to determine test section wind speed. Unnecessary wind tunnel auxiliary systems shall be shut off, including any rolling road belt system and associated components, hydraulics, etc. For parallel measurement of interior and exterior noise, it might be necessary to measure in sequence, with the traversing gear auxiliary system temporarily shut off. Operation of other machinery elsewhere in the facility, which is audible in the test section, or measureable as electronic noise, needs to be coordinated with the facility personnel.

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.

Wind noise measurements are usually performed at wind speeds specified in the VTS 3.2.1.3.8.3.1, typically 112.7 km/h (70 mph), and/or 140 km/h. Other common test speeds include 80.5 km/h (50 mph), 120 km/h, and

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