



Vehicle Level Heating and Ventilation Blower Noise and Vibration 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. This procedure describes the process for evaluating and measuring vehicle level noise and vibration (N&V) generated by Heating, Ventilation, and Air Conditioning (HVAC) blowers.

1.2 Applicability. This procedure is applicable for all passenger cars, multi-purpose passenger vehicles and light commercial vehicles with a heating and/or air conditioning (A/C) system.

1.3 Remarks. This procedure is used to assess N&V performance of heating and ventilation blowers at the vehicle level such as front and rear heat/air conditioning blowers, and rear blowers mounted in center console.

Because blower noise emission is dependent on blower airflow rate, airflow measurements are a necessary part of an objective assessment of blower noise. Airflow rate is especially important when evaluating multiple blowers. Blower noise levels from multiple blowers can be compared by relating blower noise levels to airflow rates.

2 References

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

2.1 External Standards/Specifications.

IEC 61672-1:2013 ISO 2631 ISO 5349

2.2 GM Standards/Specifications.

GMW14172 GMW14264

2.3 Additional References.

- European Computer Manufacturers Association (ECMA); ECMA-74 9th Edition, available at <http://www.ecma-international.org/default.htm>.
- Vehicle Technical Specification (VTS).

3 Resources

3.1 Facilities. All measurements shall be performed in a semi-anechoic test room free from interfering noises with low noise exhaust gas extraction system or outdoors in a free field area.

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. Microphones regionally accepted for vehicle interior noise measurements. 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 61672-1:2013 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

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October 2015

Page 1 of 14



Documents

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3.2.2 Accelerometers. High sensitivity accelerometers with a flat frequency response from 2 Hz to 2 kHz and a temperature range including 10 °C to 50 °C.

3.2.3 Data Acquisition System (DAS). 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 61672-1:2013 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

3.2.4 Digital Voltmeters. Two (2) digital voltmeters for monitoring battery voltage and blower motor voltage.

3.2.5 Variable Direct Current (DC) Power Supply. Variable DC power supply with sufficient capacity to provide at least 15 V at 50 A.

3.2.6 Tachometer (Optional for Benchmarking). Optical or inductive sensor capable of accurately measuring the blower speed in revolutions per minute (rpm).

3.2.7 Current Meter. Optional current meter for monitoring current of the blower motor.

3.2.8 Pulse Width Modulator (PWM) Controller (Optional). A device capable of variable frequency and duty cycle digital control of PWM signal to the blower motor is required for blower motors that use PWM control.

3.2.9 Vehicle Network Interface. Optional neoVI device and Vehicle Spy software from Intrepid Systems (or similar equipment) can be used to monitor and control HVAC blower fan speed, mode doors, etc.

3.2.10 Airflow Bench. Optional low-noise device capable of measuring air flow in Liters per second (LPS) through the HVAC module, such as the Windjammer produced by Flow Systems (www.flowsystemsinc.com). Ideally, the flow bench duct would be attached at the right rear window of the vehicle, furthest away from microphone locations. Likewise the flow bench must be acoustically isolated from the vehicle and duct. GMW14482, Appendix A contains more detailed descriptions of Flow Bench and Throttle Box.

3.3 Test Vehicle/Test Piece. The tests shall be performed on a vehicle that represents the current release status. Deviations (e.g., obvious faults) shall be eliminated or recorded. With the exception of competitive benchmarking, blower motor assemblies should be tested at the maximum allowed unbalance tolerance. Ensure that the hush panel is replaced if removed to install a jumper wire and/or tachometer to the blower motor.

3.4 Test Time.

Calendar time: 1 day

Test time: 4 hours for Vehicle Technical Specification (VTS) validation portion if appropriate cabling is available, more if root cause is performed

Coordination time: 3 hours

3.5 Test Required Information. For PWM controlled blower motors, the PWM operating voltage, PWM signal frequency, and PWM duty cycles representing each blower speed are required from the HVAC module supplier.

3.6 Personnel/Skills. Engineer or qualified technician with basic knowledge of acoustic data acquisition and one mechanic.

4 Procedure

4.1 Preparation. Check the vehicle according to 3.3. Install a new cabin air filter, if that feature is available. For front HVAC system measurements, rear outlets should be closed. The main blower system characteristics and design features should be recorded on the test data sheet or in the project data section. See Appendix A, Data Sheets A1 and A2 for Sample Blower Data Sheets. Record the number of blower blades, the number of blower motor pole pairs, the blower wheel diameter, the blower wheel width, blower motor type (brushed or brushless) and the blower motor unbalance condition. If the balance condition is unknown, document it as unknown. If equipped with tilt/telescope steering, position the steering column in the center position of travel for both tilt and telescope. Position front seats to mid-point position as described in Appendix C.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient air temperature should remain at $20\text{ °C} \pm 4\text{ °C}$.

All interfering noise emissions from test stand devices must be eliminated.

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.

4.2.3 Standard Test Condition. Acquire data for appropriate test conditions needed to satisfy requirements.

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October 2015

Page 2 of 14

4.2.3.1 Competitive Noise Benchmarking Steady State Test Conditions.

4.2.3.1.1 Background Noise Steady State Test Condition. With the engine off and the key turned to the on position, measure background noise with the HVAC system off.

4.2.3.1.2 Engine on Steady State Test Conditions. With the vehicle warmed up (running at idle for at least 10 minutes), the engine idling in park for vehicles with automatic transmissions (neutral for vehicles with manual transmissions) and the A/C compressor off, test the following conditions:

- HVAC System Off.
- Each discrete fan speed setting, Vent, Full Cold (FC), Outside Air Mode (OSA).
- Each discrete fan speed setting, Vent, FC, Recirculation.
- Each discrete fan speed setting, Heater, Full Hot (FH), OSA.
- Each discrete fan speed setting, Defrost, FH, OSA.
- Rear System, if applicable, with rear outlets opened.
 1. High Blower, High Outlets, FC, OSA.
 2. High Blower, Low Outlets, FC, OSA.

4.2.3.2 Standard Steady State Test Conditions (Optional for Benchmarking). Each of the test conditions listed below are required for GM vehicles for validation and should also be completed during development testing, but are optional for competitive benchmarking:

With the engine off, the key turned to the on position and the blower powered by a DC power supply and PWM controller if applicable, test the following conditions for VTS validation:

- HVAC System Off
- Each discrete fan speed setting: Vent, FC, OSA

Note: Automatic systems may force Recirculation at Vent Full Cold. To avoid this, set temperature to 1 degree above FC for OSA.

- Each discrete fan speed setting: Vent, Full Cold, Recirculation.
- Each discrete fan speed setting: Heater, FH, OSA.
- Each discrete fan speed setting: Defrost, FH, OSA.

Test other conditions if appropriate based on a thorough subjective evaluation, including but not limited to:

- Various blower speeds, Bi-Level, Full Cold, OSA.
- Various blower speeds, Defog, FH, OSA.
- Various blower speeds, Trilevel, FC, OSA.
- Various blower speeds, Trilevel, FH, OSA.
- Rear System, if applicable, with rear outlets opened,
 1. Low Blower, High Outlets, FC, OSA.
 2. High Blower, High Outlets, FC, OSA.
 3. Low Blower, Low Outlets, FC, OSA.
 4. High Blower, Low Outlets, FC, OSA.

4.2.3.3 Blower Motor Sweep (Optional for Benchmarking). With the engine off, the key turned to the on position and the blower powered by a DC power supply, perform the blower motor speed sweep test for the operating modes listed below. For a brushed motor, this is done by incrementing the voltage applied to the blower from 3 V to 14 V over approximately 1 minute. Brushless motors, however, are speed controlled, and the speed does not vary with battery voltage as long as sufficient voltage is applied. For this reason, brushless motors must be tested at approximately 14 V to 15 V, and the sweep is accomplished by adjusting PWM duty cycle from the supplier-defined minimum duty cycle (approximately 20%) to the supplier-defined maximum duty cycle (approximately 92%) over approximately 1 minute at the appropriate PWM signal frequency:

- Vent, FC, OSA.
- Vent, FC, Recirculation.

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October 2015

Page 3 of 14



Documents

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- Bi-Level, FC, OSA (optional).
- Heater, FH, OSA.
- Defrost, FH, OSA.
- Defog, FH, OSA (optional).
- Rear System, if applicable, with rear outlets opened,
 1. High Outlets, FC, OSA (optional).
 2. Low Outlets, FC, OSA (optional).

Note: For airflow measurement compatibility reasons, additional noise measurements with opened rear windows, opened trunk hood, (no backpressure) may be necessary, unless an airflow bench is capable of maintaining a set pressure differential inside the vehicle.

4.2.3.4 Blower N&V Subjective Evaluation (Optional). Perform blower N&V subjective evaluations in each of the front seats plus the seat(s) closest to any rear air outlet nozzle(s) with the vehicle engine running at idle. Evaluate all blower speeds using the subjective rating scale included in GMW14264 for each of the following conditions, including both front and rear systems. Also pay attention to the transition sounds as the blower motor changes speed, and include them in the evaluation rating. Rear systems have various methods to control and can impact front HVAC noise levels (e.g., mimic mode, rear controlled mode, off). HVAC calibration team can provide assistance:

- Vent, FC, OSA.
- Vent, FC, Recirculation.
- Bi-Level, FC, OSA.
- Trilevel, FC, OSA.
- Trilevel, FH, OSA.
- Heater, FH, OSA.
- Defrost, FH, OSA.
- Defog, FH, OSA.
- Rear System, if applicable, with rear outlets opened,
 1. High Outlets, FC, OSA.
 2. Low Outlets, FC, OSA.

All air directions and settings of the blower shall be checked and any abnormal noises shall be rated. The blower noise rating has to take into account that the customer will expect and accept higher blower noise levels at higher blower speeds.

Besides the overall sound pressure level, the subjective sound impression is important for the blower noise evaluation. The sound impression can be affected negatively by:

- Air rush noise.
- Boom/buzz noise or vibration (unbalance or panel resonances).
- Chirp/tick/click noises (carbon brushes).
- Flutter/rustle noises (due to debris in HVAC system).
- Roar/rumble noises (panel resonances).
- Squeak noises.
- Whine tonal noise (magnetic field of blower motor, rotary noise, blade passage).
- Whistle/hoot noises (air gaps).
- Modulation or changes over time.

Assess actuator noises for each door/flap motion including changes in mode, temperature, and recirculation without airflow (blower off) and with maximum airflow. Also evaluate any changes in sound as the mode and temperature doors are moving.

4.3 Instructions.

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October 2015

Page 4 of 14

4.3.1 Calibration Verification. Check equipment for valid calibration date. Replace out-of-date equipment. Perform equipment calibration verification (see GMW14172).

4.3.2 Install Instrumentation.

4.3.2.1 Microphones. Install interior microphones in positions as specified in Appendix B, Figures B1 and B2. The standard positions are Left Front Right Ear (LFRE) and Right Front Left Ear (RFLE) seat positions, the Left Rear Ear (LRE) seat position, and, if needed, the seat and ear position closest to any rear air outlet nozzle if not captured in the LRE microphone position. Install windscreens on all microphones.

4.3.2.2 Accelerometers. Install triaxial accelerometers at the driver interfaces. The standard driver interface locations include the 12 o'clock position on the steering wheel in the fore-aft, lateral and vertical directions plus the front outboard position on the driver's seat track in the vertical direction.

4.3.2.3 Blower Motor Monitoring Equipment. For competitive benchmarking tests, the next few steps (4.3.2.3 thru 4.3.2.4.1) are optional. Install instrumentation to monitor battery voltage, blower motor voltage, blower speed in rpm and blower motor current (optional).

Note: Do not backfeed voltage. Electrical monitoring equipment should not introduce voltage and/or current to the system.

For PWM blower motors, set power supply and PWM controller for appropriate PWM operating voltage, signal frequency, and duty cycle as required for the test condition.

4.3.2.3.1 Define Blower Test Speeds and Voltages. Start the engine and idle the vehicle for at least 10 minutes with all electric power consumers switched off.

Record the battery voltage, blower voltage, blower speed in rpm, and motor current (optional) for each of the test conditions in 4.2.3.2 at warm idle. Monitor battery voltage for consistency between blower conditions. Check with electrical engineer for appropriate battery voltage range (usually 13.5 V to 14.2 V).

4.3.2.4 Connect Variable DC Power Supply. Supply power to the blower motor using one of the following two (2) methods:

- Connect the DC power supply directly to the blower motor terminal.
- Replace the vehicle battery with the DC power supply. Disconnect the vehicle positive lead from the battery positive terminal. Connect the power supply positive lead to the vehicle positive lead that was disconnected from the battery. Make sure the lead is properly fused. Attach the power supply negative connection to an adequate vehicle ground. The battery negative terminal is adequate.

4.3.2.4.1 Perform Power Check. Power up the vehicle by turning the key to the on position, but do not crank or start the engine. Turn off the HVAC system. Identify and eliminate any other noise sources inside the vehicle by removing fuses from Bus Electrical Centers (BEC(s)).

Determine if the A/C compressor clutch and/or electric powertrain cooling fans turn on in defrost mode. Remove fuses to defeat those systems as required. If the A/C compressor runs during maximum cold events, run 1 degree above maximum cold.

4.3.3 Vehicle Setup. Replace all exterior and interior trim panels that were removed to instrument the vehicle. The vehicle should be unloaded except for the driver (if necessary) and the test equipment.

To minimize flow restriction, set all adjustable vent outlets, such as Instrument Panel (IP) outlets, to their fully-open position and angled as straight as possible to their supply ducts. If any vent is aimed directly towards a microphone, adjust its angle by a few degrees such that the microphone is out of the direct airflow path at maximum blower speed. Close the engine compartment hood, trunk, sliding roof, sunscreen, doors, and windows.

Ensure that A/C (compressor) is off and stabilized before performing data acquisition. Turn off the radio and other accessories. Ensure all customer actuated systems are off.

Ensure that the vehicle battery is fully charged prior to testing.

4.3.4 Data Acquisition.

4.3.4.1 Steady State Data Acquisition. Before the start of the test, verify the instrument settings and vehicle condition. Operate the vehicle and the HVAC system according to the test conditions defined in 4.2.3.1 for competitive benchmarking testing and/or 4.2.3.2 for standard testing. For standard steady state test conditions, adjust the DC power supply (and PWM controller if applicable) to match the blower speeds recorded for the test

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October 2015

Page 5 of 14



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