



Center Console or Rear HVAC Blower Module 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. To define the process for quantifying rear heating, ventilation, air conditioning (HVAC) blower module subsystem free acceleration levels at the vehicle attachment locations and the subsystem source noise levels.

1.2 Applicability. This procedure is appropriate for passenger vehicle rear HVAC blower modules and center console blower motors.

1.3 Remarks. This procedure is used to gain knowledge of the noise and vibration (N&V) behavior of a blower module at the subsystem level before prototype vehicles are available. The noise measurements made on bare blower modules are comparable to in-car HVAC system measurements except for the effect of body cavity resonances on the absolute noise level when measured in vehicle. The free acceleration response of an energized component is one of the factors affecting structure-borne noise. This quantity, with others, can be used to calculate forces into the body or be combined to predict noise levels in the vehicle passenger compartment.

2 References

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

2.1 External Standards/Specifications.

DIN 45631/A1 2010 IEC 61672-1:2013

2.2 GM Standards/Specifications.

GMW14172

2.3 Additional References.

Subsystem Technical Specification (SSTS)

3 Resources

3.1 Facilities. All measurements shall be performed in a semi-anechoic test room free from interfering noises. Background noise levels must be less than 30 dB(A) unless otherwise specified. Background noise is considered to include test room ambient noise and test equipment noise.

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. Three (3) free field measurement microphones (12.7 mm diameter) meeting class 1 accuracy corresponding to IEC 61672-1:2013 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$). Microphone preamplifier, connecting cables, power supply (if the function is not already provided by the digital sound recording system), and calibrator.

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3.2.2 Microphone Stands. Microphone floor stands or equivalent method for supporting the microphones.

3.2.3 Accelerometers (Optional). Small accelerometers (weight less than 0.006 kg), transducer cabling and signal conditioning.

3.2.4 Data Acquisition System (DAS). Multi-channel data acquisition hardware capable of calculating both frequency domain and order domain results between 0 Hz and 11.2 kHz, and have a minimum of 80 dB dynamic range. This hardware shall meet class 1 accuracy corresponding to IEC 61672-1:2003 or be equivalent for the application (precision ± 0.7 dB or $\pm 8\%$).

3.2.5 Digital Voltmeter (Optional). Digital voltmeter for monitoring voltage of the blower motor at the terminal connector to the blower motor.

3.2.6 Variable DC Power Supply. Variable DC power supply with sufficient capacity to provide at least 15 V at 50 A.

3.2.7 Pulse Width Modulation (PWM) Controller. 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.

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

3.2.9 Data Analysis System. Artemis sound quality analysis program by Head Acoustics or an equivalent analysis program.

3.2.10 Elastomeric Cords. Elastomeric cords for mounting rear HVAC blower module in vehicle orientation.

3.3 Test Vehicle/Test Piece. A complete rear HVAC blower module that represents the current part release status is required.

3.3.1 For validation, the blower motor assembly should be built to the maximum allowable unbalance tolerance. The main blower system characteristics and design features shall be recorded including the part numbers, number of blower blades, number of motor pole pairs, blower wheel diameter and width, unbalance levels and any other design features important for noise and vibration.

3.3.2 For all modules, where applicable, the use of the production released climate control electric control unit (ECU) and control panel is desired to measure DC and Stepper motor actuator noise measurements.

If the production climate control unit and control panel is not available, the actuator motors shall be tested at 13 V. It must also be assured that there is no increase of the actuator noises when the voltage varies ± 1.5 V

3.4 Test Time.

Calendar time: 1 to 2 days

Test time: 4 to 8 hours for Subsystem Technical Specification (SSTS) validation portion if appropriate cabling is available, more if root cause is performed

Coordination time: 4 to 8 hours

3.5 Test Required Information. The airflow rates included in the program specific HVAC and Powertrain Cooling SSTS should be measured or known.

3.6 Personnel/Skills. One (1) engineer or technician with basic knowledge of acoustic data acquisition are required to run this test.

4 Procedure

4.1 Preparation. Ensure that the test part meets the requirements outlined in 3.3.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient air temperature shall be between 15 °C and 25 °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 Conditions. Ensure that the climate control ECU (if applicable) and Control panel are controlling the HVAC module correctly. Involve the electrical release engineers to assist with the setup if needed. Use the control panel to select each operating condition to be tested.

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For rear HVAC Module, standard operating modes are listed in Table 1.

Table 1: Rear HVAC Module Standard Operating Modes

Mode Door Position	Temperature Door Position
Upper Outlets	Full Cold
Bi-Level (Split mode)	50%
Lower (floor) Outlets	Full Hot

4.2.3.1 Steady State Conditions. Rear HVAC module blower noise should be measured at the blower speed that achieves the desired (rated) airflow rate per SSTs.

For PWM controlled blower motors, use the operating voltage, PWM signal frequency, and PWM duty cycle representing the appropriate blower setting.

4.2.3.2 Speed Sweep. Sweep the blower motor speed by incrementing the blower motor connector voltage from 3 V to 15 V over 1 minute. For PWM systems, perform PWM duty cycle sweeps from the supplier defined minimum duty cycle for low blower setting to the supplier defined maximum duty cycle for high blower setting at the appropriate PWM signal frequency and operating voltage.

4.3 Instructions.

4.3.1 Installation. Support the complete console or rear HVAC module, as it is oriented in the vehicle, using elastomeric cords to approximate free-free boundary conditions. Adjust the vertical height of the blower motor centerline to be a minimum of 1 m above the floor. Reference Appendix A, Figures A1 and A2 and Appendix B, Figures B1 and B2 for test setup pictures and diagrams.

Note: Do not overly constrain the test part. Elastomeric cord stiffness should be as low as possible.

4.3.2 Calibration Verification. Check equipment for valid calibration date. Replace out-of-date equipment. Turn on all equipment and leave on for 5 minutes prior to measurements or calibration. Perform equipment calibration verification (see GMW14172).

4.3.3 Install Instrumentation.

4.3.3.1 Speed Sensor. Install optical or inductive speed sensor to accurately measure blower motor speed tachometer signal in rpm without disturbing the air flow or generating disturbing noises.

4.3.3.2 External Power Supply. Connect an adjustable external DC power supply and control cable to the blower motor terminal connector. The power supply will be used to adjust the voltage at the blower connector(s), the current and blower speed to the levels defined in 3.5. For PWM blower motors, set power supply voltage and PWM controller for appropriate PWM signal frequency and duty cycle as required for the test condition.

4.3.3.3 Microphones.

4.3.3.3.1 Console Blower Microphones. Install measurement instrumentation using the following microphone positions M1, M2, and M3, as shown in Appendix B, Figure B1:

- Position Microphone 1 (M1) parallel to the outlet duct 1 m from the outlet(s).
- Position Microphone 2 (M2) 1 m in the vertical direction from the floor, 1 m from the center of the blower motor and 45 degrees from the outlet duct in the horizontal plane.
- Position Microphone 3 (M3) 0.1 m next to the center line of the blower motor axis.
- Position all microphones so that they are pointing at the measured noise source. Use a wind screen for microphone M1.

4.3.3.3.2 Rear HVAC Module Microphones. Install measurement instrumentation using microphone positions M1 and M2, as shown in Appendix B, Figure B2:

- Position Microphone 1 (M1) next to the center line of the blower motor axis.
- Position Microphone 2 (M2) 1.6 m in the vertical direction from the floor and 1 m in the horizontal direction from the centerline of the middle of the HVAC module vent outlet(s).

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- Position all microphones so that they are pointing at the measured noise source. Use a wind screen for microphone M2.

4.3.3.4 Accelerometers (Optional). Install accelerometers to monitor tri-axial acceleration responses at each of the rear HVAC module and/or center console blower vehicle attachment locations.

4.3.4 Data Acquisition. Set up the DAS as defined in Section 5 when data acquisition and processing are done simultaneously.

4.3.4.1 Steady-State Noise Data Acquisition. Set up the DAS to acquire narrow band, A-weighted Sound Pressure Level (SPL) spectra using the following parameters:

- Frequency range: 22 Hz to 11 kHz
- Frequency resolution: 1 Hz to 12 Hz
- Window: Hanning, Energy Correction
- Amplitude: Root Mean Square (RMS)
- Averaging: 50 Averages, 50% Overlap
- Acquire data for each steady-state condition, as required. Record at least 10 s, two (2) averages per second, of data for each required steady-state condition.

4.3.4.2 Steady-State Acceleration Data Acquisition (Optional). Set up the DAS to acquire narrow band, linear acceleration spectra in the units of meters per second squared (m/s^2) using the following parameters:

- Frequency range: 0 Hz to 800 Hz
- Frequency resolution: 1 Hz
- Window: Hanning, Energy Correction
- Amplitude: RMS
- Averaging: 50 Averages, 50% Overlap
- Identify the applied voltage, or PWM duty cycle, that results in the highest acceleration levels. Acquire tri-axial acceleration data at each vehicle attachment location at the identified voltage.

4.3.4.3 Sweep Data Acquisition. Sweep the blower speed by incrementing the blower connector voltage from 3 V to 15 V over 1 minute. For PWM systems, perform PWM duty cycle sweeps from the supplier defined minimum duty cycle for low blower setting to the supplier defined maximum duty cycle for high blower setting at the appropriate PWM signal frequency and operating voltage.

Set up the DAS to acquire blower speed based data capable of providing the following:

- Overall A-Weighted SPL
- A-Weighted SPL order cuts at prominent blower orders

Note: Time data and waterfall data are required for post processing.

4.3.4.4 HVAC Module Power Operated Flap Adjustment Noise Data Acquisition. Acquire time data at a sampling rate of 48 kHz starting with background noise and cycling through the complete power operated flap operation range. Repeat the data acquisition sequence, as needed, for all other operating modes of the HVAC module.

Record the entire duration of the actuator and flap movement including 1 s of silence at the beginning and the end of the movement.

5 Data

5.1 Calculations. Process noise and vibration data as defined in the following.

5.1.1 Steady-State $\frac{1}{3}$ Octave Band Noise Data. Process the microphone data to calculate the overall A-weighted SPL in decibels (dB) relative to 20 μPa and the $\frac{1}{3}$ octave band data for the 25 Hz to 10 kHz frequency bands.

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