GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW15878

Exhaust System Cooldown Noise Assessment: Subjective Vehicle Level 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 is a vehicle level sound assessment procedure to allow an evaluator to subjectively evaluate and rank the level of cooldown noise of an exhaust system in a controlled manner. This test can be used to assess the performance of GM and competitive vehicles during exhaust cooldown and to establish the relationship between subjective impressions and objective measurements of the cooldown noise.

1.2 Applicability. This test procedure is appropriate for use with all cars and trucks.

1.3 Remarks. This procedure outlines a subjective evaluation and data summary process for evaluating exhaust cooldown noise. For the purpose of correlation with objective data, a microphone near an exhaust component may be used in accordance with GMW15879 Exhaust Cooldown Noise: Objective Vehicle Level Test. For exhaust subsystem validation purposes, cooldown mechanical noise may be evaluated according to GMW15880 Exhaust System Cooldown Noise Assessment: Objective Component Level Evaluation Procedure. This procedure is based on the results of the Design for Six Sigma (DFSS) project number 1368.

2 References

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

2.1 External Standards/Specifications.

SAE J1470

2.2 GM Standards/Specifications.

GMW8460 GMW14891 GMW15879 GMW15880
GMW14485

2.3 Additional References.

- Design for Six Sigma (DFSS) project number 1368: Epsilon Exhaust Cooldown Tick/Ping Noise Elimination.
- GM Research and Development (R&D) Report AS-598, “Hearing Acuity Standard for Squeak and Rattle Evaluators”.

3 Resources

3.1 Facilities. Appropriate designated test roads, approved public roads, or a vehicle chassis dynamometer in accordance with GMW15879. Test site must be free of obstacles that could reflect sound. Test site must be free of non-vehicle induced noise. Test is to be carried out when the wind speed is below 5 m/s, the ambient air temperature is within the range of 5 °C to 30 °C and the background noise level is 10 dB(A) below the lowest sound levels being evaluated. Reference GMW8460 and SAE J1470, Section 5.

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. Stopwatch.

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3.3 Test Vehicle/Test Piece. The test shall be performed on a vehicle that represents the current production or current part release status. For GM vehicles, the exhaust system used for testing shall be a “new” production tooled exhaust system that has been preconditioned according to 4.1.1. Any additional preconditioning or “aging” must be documented according to 4.1.1.2.Verify and record the status of all hardware relative to the current release status. Record the exhaust system part numbers. Record the testing date, time, ambient temperature and test location. Deviations (e.g., obvious faults) shall be eliminated or recorded.

3.4 Test Time.

Calendar time:	1 day
Test hours:	4 hours
Coordination hours:	1 hour

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. At least three (3) people are needed; one (1) driver and two (2) or more evaluators. These people should be qualified or trained in performing noise and vibration emulators.

3.6.1 Auditor Skill Level. Novice evaluators shall have completed three (3) prior full vehicle subjective noise evaluations under the direct supervision of an experienced Noise and Vibration (N&V) evaluator. Reference GMW14485.

3.6.2 Hearing Requirements. It is recommended that all evaluators for noise evaluations have a hearing test performed and be aware of their limitations. Any professional hearing test is acceptable, but the following test is given as a reference: GM Research and Development (R&D) Report AS-598, “Hearing Acuity Standard for Squeak and Rattle Evaluators”.

4 Procedure

4.1 Preparation.

4.1.1 Exhaust Preparation.

4.1.1.1 Exhaust System Preconditioning. All new “out of the box” exhaust systems shall be preconditioned by operating the engine to achieve a steady temperature in the gas stream at the inlet of at least 500 °C for a minimum of 30 minutes.

4.1.1.2 Exhaust System Aging (Optional). In certain instances, it is desirable to test aged exhaust components. The aging process shall be established independent of this procedure by the appropriate GM program engineer. The aging process shall be documented with the data in terms of duration; kilometers and/or time, exhaust gas temperatures and vehicle operating schedule.

4.1.2 Thermocouple Installation (Optional). In some instances, it is necessary to record the temperature of the exhaust surface or gas stream during the evaluation. Refer to GMW15879 for information on thermocouple specifications, locations and installation techniques. Examples of instances that may require thermal data are correlation with measurements made according to GMW15879 or GMW15880.

4.1.3 Determine Evaluator Position. A subset of the global exterior microphone locations as described in Appendix A shall be used for evaluation purposes. The evaluator shall be positioned 1.0 m from the vehicle per Appendix A. For benchmarking purposes, evaluators shall be located (per Appendix A pictograph) at MG4, MG5, MG10, and additional locations as necessary. For product development purposes, the test engineer is responsible for identifying the locations which demonstrate the majority of the objectionable noise. This can be determined during a trial run as described in 4.3.

4.1.4 Evaluator Setup. Assemble evaluators as needed at the designated test location to subjectively determine the level of exhaust cooldown noise. Evaluators are to fill out the evaluation sheet (Appendix A) header information for the vehicle and exhaust system. Use one (1) sheet per evaluation.

4.1.5 Microphone and Recording Device Setup (Optional). Refer to GMW15879.

4.2 Conditions.

4.2.1 Environmental Conditions. Confirm that the environmental conditions meet the requirements defined in 3.1. If conditions are outside of the specified range, make a note in the test log.

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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 Vehicle Conditions. Check that the vehicle conditions meet the requirements outlined in 3.3. If there are any pertinent issues, make a note in the test log.

4.3 Instructions. Each evaluator is given the evaluation sheets in Appendices A and B. The facilitator shall review Appendix B to ensure all evaluators understand how to perform the evaluation.

4.3.1 Exhaust System Warmup Procedure. The exhaust system can be brought up to operating temperature by one (1) of the following two (2) methods:

- Driving the vehicle on the designated road system as described in 4.3.1.1.
- Operating the vehicle on a chassis dynamometer according to GMW15879.

4.3.1.1 Start the vehicle. Drive the vehicle on a level road surface at a speed of 100 km/h in the highest gear available for 8 minutes to 10 minutes.

4.3.1.2 Execute one (1) of the two (2) options in the following subparagraphs depending on the availability of road surfaces:

4.3.1.2.1 Perform three (3) sequential Wide Open Throttle (WOT) runs on a level road surface. Accelerate the vehicle at WOT from a standing start (do not brake torque) in the highest customer available gear without wheel spin such that the vehicle reaches rated engine speed before up shifting. (Reference the transient back pressure test procedure in report GMW14891, but eliminate the down time between runs).

4.3.1.2.2 Accelerate up a grade for a distance of approximately 300 m with the accelerator pedal fully depressed allowing the vehicle to shift. An example is the 7.2% grade at the Milford Proving Grounds (MPG).

4.3.1.3 Drive the vehicle over to the designated evaluation area alongside of any evaluators. The time between the end of the acceleration event and the vehicle shut off should be no more than 3 minutes. If a microphone and recording device are to be used, set up the microphone quickly and begin recording concurrent with the start of the subjective evaluation.

4.3.2 Evaluation. All evaluators shall stand in one (1) of the global exterior zones shown on the evaluation sheet in Appendix A. The facilitator shall call out the start of the test and then indicate each 1 minute mark. The evaluators shall rate the cooldown noise as described in Appendix B. Evaluators shall document responses on the Appendix A evaluation sheet.

4.3.3 Repeat the process as required.

5 Data

5.1 Calculations. The data collected from the evaluation sheets can be compiled and plotted on a bubble chart by splitting the x-axis into time intervals and the y-axis into loudness ranges (low, medium and high). The bubble sizes will represent the number of occurrences (refer to Appendix C; C1, C2 and C3). Refer to GMW15879 for information on creating bubble charts using objective data.

5.2 Interpretation of Results. The bubble charts can be used to compare multiple exhaust systems, however, when dealing with a subjective evaluation, each evaluator is going to have a differing perception of the amount and loudness of any uncharacteristic exhaust noise. What is being evaluated is whether the observed noises are deemed excessive in occurrence and/or loudness. At the end of the evaluation, evaluators will be prompted to conclude the acceptability or unacceptability of the evaluated exhaust system. The resulting summaries can be used to make a determination of whether the observed cooldown noise is acceptable.

5.3 Test Documentation. This test is documented on the evaluation sheets which the evaluators fill out during the test (see Appendices A and B).

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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