GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW8518

Subjective Squeak and Rattle Evaluation: Vehicle Level

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 implement a worldwide uniform process for evaluating the Squeak and Rattle (S&R) performance of a complete vehicle. This includes the detection, the evaluation (by subjective rating of S&R complaints), as well as some root source analysis. Furthermore, the documentation of S&R complaints and the results of the root source analysis are described for initiation of problem resolution. This procedure consists of three (3) parts: Quasi-static evaluation(s), dynamic road simulation evaluation(s) (where available) and dynamic on-road evaluation(s).

This procedure also provides detailed instructions for temperature evaluations using an environmental road simulator.

1.2 Applicability. For all passenger cars, light commercial trucks and medium duty trucks.

1.3 Remarks. This procedure will guide an evaluator through full vehicle S&R evaluations. S&R performance shall be evaluated according to the GMW14264 subjective rating scale.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW7294 GMW7699 GMW14264

2.3 Additional References.

- GM Research and Development (R&D) Report AS-598. “Hearing Acuity Standard for Squeak and Rattle Evaluators” (available at https://gmweb.gm.com/sites/gmlibrary/Pages/home.aspx or contact the Program S&R Engineer).

3 Resources

3.1 Facilities.

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.

3.1.3 Facilities for Quasi-static Evaluations. Utilize an area with ambient sound pressure level less than 53 dB to evaluate the vehicle for squeaks and rattles. The quiet room shall be enclosed within an environmental chamber capable of maintaining a range of temperatures from -30 °C to +50 °C.

3.1.4 Facilities for Dynamic Road Simulations. Utilize a road simulator with appropriate road inputs enclosed within a quiet test cell capable of maintaining a range of temperatures from -30 °C to +50 °C.

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3.1.5 Facilities for Dynamic On-Road Evaluations. Utilize the appropriate road systems associated with each test facility as documented in Appendix A, Tables A1 and A2. Reference Appendix A for a comparison of road inputs with regional examples. All regions will utilize, at a minimum, the roads identified in Appendix B, B1 (Global Common Minimum Dynamic Schedule). Any exceptions from this minimum road schedule must be reviewed and approved by the Squeak and Rattle Global Harmonization Team. For regional dynamic schedules, see Appendix B, B2 through B9.

3.2 Equipment.

3.2.1 Equipment for Dynamic Road Simulations. Utilize a road simulator with appropriate road inputs. A quiet test cell with a road simulator consisting of a 4-post hydraulic shaker capable of providing separate road inputs to each vehicle corner is required. The environmental road simulators shall also be equipped with solar lamps, used to heat vehicle interior surfaces.

3.2.2 Tools. A list of common listening tools for S&R Root Source can be obtained from the Program S&R Engineer.

3.3 Test Vehicle/Test Piece. A “design intent” test vehicle, which reflects the development or production status of the appropriate build phase, shall be used to subjectively evaluate S&R vehicle level performance. Vehicle for test should not be significantly modified from the condition in which it left the build site. Experience has shown that disassembly/reassembly of vehicle components and subsystems can introduce non-representative S&R noises.

3.4 Test Time. Table 1 and Table 2 provide an estimate of the time (work hours) needed to perform various portions of this procedure. Consider preparation, downtime and analysis of data in determining the total calendar time required. Depending on facilities locations, as well as vehicle content, and the number of S&R noises detected, the test duration may vary significantly. It is also noted that there regional differences in the number of people and duration required and that the following tables are shown as a guideline only.

Table 1: Example Test Time Schedule (Road Simulator Located at Proving Ground)

Technician Resource:	21 h
Engineer Resource:	24 h
Total Calendar Duration:	4 days

Note: Duration varies over tested temperature points.

Evaluation:	**Day 1**	**Day 2**	**Day 3**	**Day 4**
Quasi-static:	2 h	1 h	1 h	1 h
Dynamic Road Simulation:	1 h	1 h	1 h	1 h
Dynamic On Road:	3 h	----	----	----
Root Source:	2 h	1 h	1 h	1 h

Table 2: Example Test Time Schedule (Road Simulator NOT Located at Proving Ground)

Technician Resource:	21 h
Engineer Resource:	24 h
Total Calendar Duration:	5 days

Note: Duration varies over tested temperature points.

Evaluation:	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Quasi-static:	2 h	2 h	1 h	1 h	1 h
Dynamic Road Simulation:	----	4 h	1 h	1 h	1 h
Dynamic On Road:	4 h	----	----	----	----
Root Source:	2 h	2 h	1 h	1 h	1 h

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3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills.

3.6.1 Auditors. Evaluators can work by themselves or with the help of others. Generally, when driving on the road systems, a second occupant is recommended.

3.6.2 Auditor Skills. Each evaluator shall be trained in S&R noise/sound identification and techniques, as well as root source analysis methods.

3.6.3 Hearing Requirements. Vehicle auditors for S&R must have an Audiological test performed on both ears. Threshold shift at pure tone frequencies of 500 Hz, 1000 Hz, 2000 Hz, and 3000 Hz must be measured. If the decibel loss in each ear averaged over the four (4) test frequencies is ≤ 25 dB, the subject meets the minimum hearing qualification for auditing squeaks and rattles. If the averaged shift in either ear is > 25 dB, the subject does not meet the minimum qualification. This requirement is per GM R&D Report AS-598.

4 Procedure

4.1 Preparation.

4.1.1 All equipment which is required for using a vehicle on public roads (legal requirements and standard features) has to be in/on the vehicle. The equipment has to be placed and fixed at the provided locations, e.g., first aid box, warning triangle, license plate, vehicle tools, spare wheel, towing hook, etc.

4.1.2 Affix or remove any parts that are not installed correctly.

4.1.3 Remove loose items from glove box and other compartments.

4.1.4 Remove any non-production items from the vehicle, e.g., camouflage and plastic film over seats.

4.1.5 Install any available optional parts to be included in vehicle test.

4.1.6 Remove stickers on the windows if they cause unwanted noise. If stickers cannot be removed, do not include the sound associated with the sticker(s) in the evaluation.

4.1.7 Ensure vehicle is clean and dry prior to evaluation.

4.1.8 The recommended fuel level is between ¼ and ¾ full.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

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.

4.2.2.1 Road Simulator Evaluations. The evaluations should be performed according to the temperature provided in Appendix E, Figure E1.

4.2.2.2 Proving Ground Road System Evaluations. Roads used for the dynamic evaluations should be dry and without standing water. The wind speed should be < 25 km/h.

4.3 Instructions. The following are general statements associated with making subjective S&R evaluations using the subjective scale rating found in GMW14264.

Rate each S&R independently of the vehicle market segment.

When the same issue is encountered in more than one (1) of the test evaluations (Quasi-static, Dynamic Road Simulation or Dynamic On-Road), rate and record the S&R separately in each of the sections.

Evaluate each S&R separately for every mode of operation. For example, if a noise is heard from the glove box during both opening and closing motions, two (2) separate ratings should be assessed.

When evaluating on a simulator from the back seat, do not record driver's seat issues that were also noted from that location. However, if the same noise is heard from multiple locations in the vehicle, the lowest subjective rating should be recorded.

A separate subjective rating value should be established for similar parts in different locations. For example, if the left front door has a rattle and the right rear door has a rattle, they should be recorded as separate items.

Operate each component with typical force.

Any and all seat positions can be used to perform assessments.

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4.3.1 Quasi-static Instructions. A general Quasi-static checklist, as found in Appendix D, Figure D1, can be used to help in this assessment. This checklist is included as an example and may be updated as needed for testing.

Vehicles for test may include new or innovative content and/or optional equipment not included in this list. Any and all compartments, levers, buttons, knobs, etc., must be operated according to typical expected customer usage to ensure a complete Quasi-static evaluation.

Operate each required component a minimum of three (3) times.

All configurations and/or position of each subsystem/component must also be subjected to moderate hand flexure forces and moderate hand impacts at locations where vehicle occupants are likely to contact the subsystem or component. This part of the test should also include normal passenger motion, especially for the seat evaluation.

4.3.1.1 Exterior Closures. Turn ignition to “on”. Turn “off” all accessories including the Heating Ventilation and Air Conditioning (HVAC) system.

Evaluate for squeaks and rattles from outside the vehicle for the following closure systems, if vehicle is so equipped, and record the subjective rating score on a form similar to that found in Appendix F, Data Sheet F1.

4.3.1.1.1 Side Swing Door Sound. Open and close all doors with glass in the full “up”, “half way” and full “down” positions. Glass should be in the “up” position on all doors not being evaluated.

Note: If the vehicle has a convertible top or removable roof panel(s), the door closing shall be evaluated as follows: Top raised or panel(s) installed and windows in the full up, half way and full down positions. Then again with the top retracted or panel(s) removed and windows in all three (3) positions. When measuring the second condition, use the same door closing force as used in the top up or panel(s) installed condition.

Note: If the vehicle’s door window glass lowers slightly when door is opened and rises when closed, the door closing shall be evaluated in two (2) configurations: Full down and half way.

4.3.1.1.2 Manual/Power Sliding Door(s) Sound.

4.3.1.1.2.1 Position the door just forward of the rear detent.

4.3.1.1.2.2 Pull the door forward with a quick typical force to allow the door to slide freely forward and engage the latch in the case of manual door(s) or push the “close” button for power sliding door(s).

4.3.1.1.3 Hood/Decklid/Lift Gate/Lift Glass/Tailgate Closing Sound/Spare Tire Swing Gate.

4.3.1.1.3.1 Open the closure enough to allow gravity to close the closure when possible. If the closure requires additional force to close, let go of the closure as quickly as possible. Avoid pressing the closure shut.

4.3.1.1.3.2 With rear hatch open, cycle any rear compartments, cargo covers or foldable seats.

4.3.1.1.4 Fuel Filler Door – Manual/Electrical. Evaluate for squeaks and rattles (if electric or manual cable, do so from the driver’s seat). Evaluate the closing sound from the door location.

4.3.1.2 Interior Systems Sound. Ignition remains “on”. All accessories, including the HVAC system, remain “off”.

4.3.1.2.1 Driver’s Seat Evaluations. From the driver’s position, evaluate for squeaks and rattles and record the subjective rating level.

4.3.1.2.1.1 Driver’s Door. Cycle door with glass in the up, half way and down positions.

4.3.1.2.1.2 Windows. Cycle all windows from master switch.

4.3.1.2.1.3 Console Lid. Hold the console lid open approximately 125 mm and let the lid fall closed.

4.3.1.2.1.4 Glove Box Door.

4.3.1.2.1.4.1 Open the glove box door and allow it to fall to full open.

4.3.1.2.1.4.2 Push the glove box door closed, letting go just before striker engagement.

Note: If the door fails to latch when using a typical force, then provide a minimal amount of force to press the door closed.

4.3.1.2.1.5 Any Specialty Compartments Accessible from Front Seat. Examples: Additional storage compartments, sunglass holders, foldable handholds, etc.

Cycle the components through their full operating range.

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4.3.1.2.1.6 Cup Holder(s). Cycle the cup holders.

4.3.1.2.1.7 Ashtray. Cycle the ashtray (if so equipped).

4.3.1.2.1.8 Sun Visor/Vanity Mirror.

4.3.1.2.1.8.1 Cycle all front sun visors up/down, side to side and push/pull sun visor extension.

4.3.1.2.1.8.2 Cycle the sun visor mirror cover up/down.

4.3.1.2.1.9 Steering Column Manual/Power. Tilt/telescope the column in all positions.

4.3.1.2.1.10 Shifter. Cycle the shifter in all positions.

4.3.1.2.1.11 Parking Brake/Brake Pedal/Clutch Pedal. Depress the pedal or lift the handle and then release parking brake.

4.3.1.2.1.12 Seat Belt Buckle Engagement.

4.3.1.2.1.12.1 Actuate the diver seat belt buckle.

4.3.1.2.1.12.2 Extract enough excess webbing to allow insertion of the latch into the buckle to eliminate webbing friction sounds.

4.3.1.2.1.13 Seat Belt and Height Adjuster. Move the adjuster through all its operating range.

4.3.1.2.1.14 Turn Signal Stalk.

4.3.1.2.1.14.1 Place the turn signal stalk in the neutral position.

4.3.1.2.1.14.2 Move the stalk through its range of motion.

4.3.1.2.1.15 Sunroof Sunshade. Cycle the sunshade full travel in all modes of operation.

4.3.1.2.1.16 Power/Manual Sunroof.

4.3.1.2.1.16.1 Move the sunroof sunshade (if so equipped) to the open position and the sunroof glass to the closed position.

4.3.1.2.1.16.2 Cycle sunroof glass from full close to vent and from vent to full close.

4.3.1.2.1.16.3 Cycle the sunroof glass from full close to full open and from full open to full close.

4.3.1.2.1.17 Power Seat Adjuster.

4.3.1.2.1.17.1 Place the seat in the full down and full rearward position.

4.3.1.2.1.17.2 Position the seat back to the evaluator's normal driving position.

4.3.1.2.1.17.3 Cycle the seat from full rearward to as far forward as is comfortable with the steering wheel, and from this forward position to full rearward.

4.3.1.2.1.17.4 Place the seat in the full rearward and full down position.

4.3.1.2.1.17.5 Cycle the seat front tilt from full down to full up and from full up to full down.

4.3.1.2.1.17.6 Cycle the seat rear tilt from full down to full up and from full up to full down.

Note: If the seat has two (2) individual up/down motors, one (1) for the front tilt and one (1) for the rear tilt, then evaluate both motors working simultaneously in the up and down directions, in addition to moving each motor individually.

4.3.1.2.1.18 Power Seat Recliner.

4.3.1.2.1.18.1 Place the seat in the full down and full rearward position.

4.3.1.2.1.18.2 Maintain contact with the seat back throughout the entire movement of the seat back during the evaluation.

4.3.1.2.1.18.3 Move the seat back to the upright (90°) position.

4.3.1.2.1.18.4 Cycle the seat back from the upright position to full rearward tilt and from full rearward tilt to the upright position.

4.3.1.2.1.19 Power/Manual Headrest. Cycle headrests on both front seats from full up to full down position.

4.3.1.2.1.20 Power Seat Lumbar.

4.3.1.2.1.20.1 Place the seat cushion and seat back to the evaluator's normal driving position.

4.3.1.2.1.20.2 Place the lumbar in its middle position in the fore/aft direction and evaluate the sound of moving the lumbar from top to bottom and from bottom to top.

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4.3.1.2.1.20.3 Place the lumbar in its middle position in the up/down directions and evaluate the sound of moving the lumbar from the fore to aft position and from the aft to fore position.

4.3.1.2.1.21 Power Convertible Top (if so equipped).

4.3.1.2.1.21.1 Unlatch the attachment to the front header (if required).

4.3.1.2.1.21.2 Cycle the convertible top moving from the closed to retracted position and from the retracted to the closed (or partially closed if equipped with a manual front header latch) position.

4.3.1.2.1.22 Power Outside Rearview Mirror.

4.3.1.2.1.22.1 Position the driver's front door window to the full down position.

4.3.1.2.1.22.2 Place the mirror in its middle position in the inboard/outboard direction and evaluate the mirror from top to bottom and from bottom to top for squeaks and rattles.

4.3.1.2.1.22.3 Place the mirror in its middle position in the up/down direction and evaluate the mirror from top to inboard to outboard and from outboard to inboard for squeaks and rattles.

4.3.1.2.1.23 Power Door Locks. Lock and unlock the power door locks.

4.3.1.2.1.24 HVAC. Cycle through all modes and through all blower speeds.

4.3.1.2.2 Second/Third Row Seat Evaluations. From the diagonal **second/third** row seat position (from driver, if present), evaluate and record the subjective rating level.

4.3.1.2.2.1 Rear Door. Cycle door with glass in the up, half way and down positions.

4.3.1.2.2.2 Any Specialty Compartments Accessible from Rear Seat. Examples: Additional storage compartments, foldable handholds, pass-throughs, etc.

Cycle the component through its full operating range.

4.3.1.2.2.3 Seat Belt Buckle Engagement.

4.3.1.2.2.3.1 Actuate the rear seat belt buckle.

4.3.1.2.2.3.2 Extract enough excess webbing to allow insertion of the latch into the buckle to eliminate webbing friction sounds.

4.3.1.2.2.4 Power/Manual Headrests. Cycle headrests in all second row seat location from full up to full down positions.

4.3.1.3 Additional Seating Evaluations. Additional evaluations of components or subsystems can be made from additional seating positions. The preceding steps can be used as a guideline when making these additional evaluations from other seating locations.

4.3.2 Dynamic On-Road Evaluation Instruction. Each GM Test Facility has a series of roads deemed appropriate in the identification of squeaks and rattles, as detailed in Appendix B, B2 through B9. While driving the prescribed course, note squeaks and rattles and their severity using the subjective rating scale. When appropriate, stop and record ratings.

Accessories such as the sunroof, sunroof shade, ashtray, two (2) front windows, headrests, sun visors and cargo shades, etc., should be evaluated in opened and closed positions to simulate customer conditions. Optional available parts should be also evaluated installed and in all possible positions or adjustments. While performing this evaluation, the radio shall be off, the HVAC shall be turned off (or set to the lowest fan speed) and the windows shall be closed.

4.3.3 Dynamic Road Simulation Evaluation. Load the vehicle onto a 4-post road simulator. If so equipped, disable the vehicle's steering column lock, usually achieved by turning the ignition switch to "on". Turn off the HVAC system. Automatic transmission should be shifted to "park", manual transmissions should be left in gear with the engine off. Typically, the parking brake should be disengaged to avoid rubbing noises between the rear tires and the simulator's wheel pans.

4.3.3.1 Run through the regionally defined Audit sequence, comprised of a series of the general types of road inputs found in Table A1 and Table A2 of Appendix A, as many times and from as many seating locations as deemed necessary to identify squeaks and rattles. Record all S&R noises heard and their subjective rating level on an evaluation sheet. An example sheet is shown in Appendix F, Data Sheet F1. Individual simulated roads and sine sweeps can be run for additional root source analysis.

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4.3.3.2 Items such as sunroof and sunshade, ashtrays, rear armrest, headrests, consoles and cup holders are to be cycled and evaluated while the simulator is in operation.

4.3.3.3 Run through an additional pass of the Audit sequence with all windows “up”. Walk around the outside of the vehicle at an approximate distance of 1.5 m. Record subjective ratings of noises heard.

4.3.4 Temperature Testing on Dynamic Road Simulator. When testing under extreme environmental conditions, the following supplemental steps and variation to ignition and HVAC settings are to be followed:

4.3.4.1 Install Interior Thermocouple. The vehicle will be considered “stable” at a given temperature when the thermocouple located in the interior of the instrument panel (behind or inside of the glove box) reads a constant temperature for 20 minutes.

4.3.4.2 When changing the environmental chamber temperature, the following steps should always be executed:

4.3.4.2.1 Ramp the chamber temperature to the prescribed temperature and wait for the vehicle temperature to stabilize as defined in 4.3.4.1.

4.3.4.2.2 Solar lamps may be used over the windshield to simulate temperatures achieved with sun load.

4.3.4.2.3 Once a stable temperature is reached at the interior, the vehicle is ready for evaluation.

4.3.4.3 When testing at each temperature, the following steps should always be executed:

4.3.4.3.1 Perform a Quasi-static Evaluation.

4.3.4.3.2 If between a Quasi-static Evaluation and Dynamic Road Simulation Evaluation the interior temperature drifts, restabilize to the prescribed value before proceeding.

4.3.4.3.3 Perform a Dynamic Road Simulator Evaluation by running the regionally defined Audit sequence on the road simulator with the engine off.

4.3.4.3.4 Identify root source of each unique noise.

4.3.4.3.5 Before proceeding, make sure exhaust vent is working properly and is attached to the vehicle’s tailpipe.

4.3.4.3.6 Perform a Dynamic Road Simulator Evaluation by running the regionally defined Audit Sequence on the road simulator with the engine running and the HVAC fan on low speed to warm the vehicle’s interior (if testing below room temperature) or cool the vehicle’s interior (if testing above room temperature). If so equipped, also use seat heater or seat ventilation. This will help to identify noises generated by expansion/contraction of parts as temperatures change. This is particularly relevant for HVAC ducts and components as well as seat components and side door weatherstrips. Engine and HVAC system should be operated until an interior temperature change of approximately 3 °C to 5 °C is achieved as determined from the thermocouple installed in 4.3.4.1.

4.3.4.4 After each of the Dynamic Road Simulation runs at the defined temperature, the engine should be turned “off” and the windows lowered or side doors opened (unless heating with solar lamps) when adjusting to the new temperature requirement. When heating interior components with solar lamps, it is best to keep side doors and windows closed.

4.3.4.5 An example Environmental Testing Temperature Flow Chart is shown in Appendix E.

4.3.5 Audio Evaluation. Perform Entertainment-System Driven S&R Evaluation per GMW7699. In addition to the test tones recommended in the procedure, play several types of regional music and spoken words.

5 Data

The following steps shall be done for each complete vehicle evaluation:

Record vehicle data, test data and the environmental conditions (temperature, humidity if applicable) for each evaluation.

Identify the S&R noise, rate it and document it on the evaluation form. The result of this step should include the noise or sound and the specific location where noise is generated (the root source).

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. A local worksheet looking similar to the one shown in Appendix F, Data Sheet F1, is used to record the subjective ratings, their source and type of noise.

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