



Speaker Validation and Reliability Test Specification

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 document is the GM World Standard for speaker component Analysis (A), Development/Evaluation (D), Design Validation (DV), and Product Validation (PV) procedures as well as environmental and reliability demonstration tests for automotive and light duty truck applications.

Provides established common validation tests or methods for GM that will be delegated to be performed either on the vehicle, buck, subsystem, component, and/or bench.

The Component Technical Specification (CTS) and Subsystem Technical Specification (SSTS) shall take precedence over this document.

In the event of a conflict between the text of this specification and the documents cited herein, the text of this standard takes precedence.

1.2 Applicability. This standard applies to all speakers and any of their external components used in cars and light-duty trucks.

1.3 Remarks. This document establishes a centralized set of electrical and mechanical validation methods and tests for GM speaker components and subsystems. Performance requirements shall be established in accordance to the Validation Test Plan, SSTS, and CTS for each appropriate level.

The Analysis procedures are used to aid in designing reliability into the product. The Development/Evaluation tasks are to be performed on first samples to provide a quick assessment of the product's capability.

Note: High-risk design validation tests shall also be run during the development/evaluation phase.

The DV section of this standard describes environmental, durability and capability tests for speakers for passenger vehicles and light duty trucks.

The reliability section of this standard describes analytical and test methods that would demonstrate reliable operation of the electrical/electronic (E/E) equipment during their expected life in the vehicle.

The design validation tasks and reliability tests are to be executed on prototype parts. Typical test sequences are in Appendix A, Figure A1.

PV testing has been reduced with the requirement of part compliance to DV testing and no significant changes to the part design. Those changes deemed significant by the GM Engineering will require complete DV and PV testing.

The product validation tasks are to be run on pilot or production parts.

The supplier is required to support and participate in subsystem or vehicle level Analysis/Development/Validation (A/D/V) tasks as specified in the Statement of Requirements (SOR), CTS, or by GM Engineering.

CG5281 Clarification to the Specification and CG5280 Speaker Test Flow - Additional Tooling – Refresh provide additional information the supplier may find useful.

1.4 Reliability.

1.4.1 Reliability Demonstration. The Component Technical Specification (CTS) reliability requirement can be demonstrated by using the analysis and/or design validation procedures.

Vibration: The analysis process shall simulate the vibration procedure in the design validation section to demonstrate the vibration reliability.

Thermal Fatigue: The analysis procedure shall simulate the thermal shock and power temperature procedures in the design validation section to demonstrate the reliability requirements. If the reliability is demonstrated by analytical methods, then the Power Temperature Cycle Test cycles can be reduced to the minimum number of cycles (200) defined in GMW3172 section titled, Power Temperature Cycle Test, providing that the product is exercised for the required number of usage cycles.

1.4.2 Reliability Demonstration by use of Highly Accelerated Life Test (HALT) Methods. The HALT methods described in this document are not intended for a quantitative reliability demonstration. The HALT procedures shall be used for two purposes:

- a. To determine the design limits in order to assess the ruggedness of the product.
- b. To develop a limited HALT procedure for usage during the product validation phase.

2 References

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

2.1 External Standards/Specifications.

EN 60529	IEC 529	IEC 60268-5	IEC 61164
IEC 225	IEC 651-5	IEC 61014	SAE J2412

2.2 GM Standards/Specifications.

9981285	GMW3172	GMW14011	GMW14833
9985821	GMW3191	GMW14124	GMW14872
GMW3059	GMW3259	GMW14444	GMW16449

2.3 Additional References.

- Armor All PN 1052911
- Armor All PN 12345002
- Capture PN 1050429
- CG5280 Speaker Test Flow - Additional Tooling - Refresh
- CG5281 Clarification to the Specification
- Component Technical Specification (CTS)
- GM Goodwrench® PN 12378401
- Momentive Performance Materials Incorporated, reference PN 39661, SM2140, 49796 SM2164 or PN 21838 (1 kg)/21837 (15 kg) TSM632
- Statement of Requirements (SOR)
- Statement of Work
- Subsystem Technical Specification (SSTS)

3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities.

3.1.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.1.2 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.

3.1.2 Equipment.

3.1.2.1 Electrodynamics vibration generator within a frequency range of 10 Hz to 2000 Hz.

3.1.2.2 Direct Current (DC) sources ≤ 5 V.

3.1.2.3 Sine wave noise generator.

3.1.2.4 Test signals:

- Sine wave signals to IEC 60268-5
- Broadband/narrow-band noise according to IEC 60268-5

3.1.2.5 Low frequency (LF) amplifier according to IEC 60268-5**3.1.2.6 Microphone amplifier and measuring microphone according to IEC 60268-5.****3.1.2.7 Third-octave filter according to IEC 225.****3.1.2.8 Ohmic resistor suited to the nominal impedance of the speaker with an accuracy of $\pm 1\%$ and a loading capacity of ≥ 20 W.****3.1.2.9 Sound baffle to IEC 60268-5.****3.1.2.10 Voltmeter according to IEC 651-5.****3.1.2.11 Frequency analyzer.****3.1.2.12 Acoustic measuring environment according to IEC 60268-5.****3.1.3 Test Vehicle/Test Piece.** The sources of samples are summarized as follows. See Section 1 for details.

3.1.3.1 The Development/Evaluation tasks shall be performed on the first samples. **Note:** Perform high-risk design validation on development samples.

3.1.3.2 Perform design validation and reliability tests on prototype parts.

3.1.3.3 Perform validation on pilot or production parts.

3.1.4 Test Time. See Section 4 tests.**3.1.5 Test Required Information.** Not applicable.**3.1.6 Personnel/Skills.** Not applicable.

3.2 Preparation. The test samples shall be production intent design and materials for design validation and manufactured on production tooling, with production materials and processes for product validation.

3.3 Conditions.**3.3.1 Environmental Conditions.** Not applicable.

3.3.2 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.

Unless stated otherwise, Table 1 shall define the test environment parameters and tolerances to be used for all validation testing:

Table 1: Parametric Tolerances

Parametric	Tolerance
High Temperature	$(+85 \pm 3) ^\circ\text{C}$
Room Ambient Temperature	$(+23 \pm 5) ^\circ\text{C}$
Low Temperature	$(-40 \pm 3) ^\circ\text{C}$
Test Time	Specification $+2/-0\%$
Room Ambient Relative Humidity	$(50 \pm 20)\%$
Chamber Humidity	Specification $\pm 5\%$
Voltage	Specification ± 0.1 V (as measured at the module)
Vibration	Specification $\pm 0.2\text{G}$ or Specification $\pm 20\%$ (whichever is greater)
Mechanical Shock	Specification $\pm 20\%$
Frequency	Specification $\pm 1\%$

3.4 Instructions.

3.4.1 Preconditioning. All speakers are to be conditioned prior to testing per IEC 60268-5, Preconditioning. Alternative preconditioning may be allowed if approved by GM Validation.

3.4.2 Operating/Non-Operating Tests. Unless otherwise specified the device(s) under test (DUT) will be in either an operating or non-operating state during testing.

3.4.2.1 Operating Test. Parts that are powered during testing will have a signal of pink noise at one-third ($\frac{1}{3}$) of maximum root mean square (RMS) power rating of speaker, at defined speaker nominal impedance, cycled 1 minute on and 1 minute off for the entire test cycle.

Unless otherwise specified, if a crossover external to the speaker driver exists, testing shall be done with the external crossover in place.

3.4.2.2 Unpowered Test. Parts that are unpowered shall not see any input signal other than those required to perform functional/parametric checks (per 3.4.4.1).

3.4.3 Functional, Parametric, Continuous Monitoring Tests and Functional Check. The Functional/Parametric Tests are procedures, which verify the functional and parametric requirements. The Continuous Monitoring Tests verify that the functional requirements are met while the DUTs are being exposed to the test environment.

All DUTs shall meet functional performance (electrical and mechanical) and appearance parameter(s) at initial, during, and endpoint of each test. Each DUT shall minimally have initial and final endpoints taken unless otherwise approved by the platform/program engineering. In the case of long term life reliability testing, midpoint testing may be required as a minimum. Monitoring of units during a reliability test is mandatory when the test is designed as a reliability improvement/demonstration test, so that the test time to failure is recorded for data analysis and reliability calculations. If the reliability/life test is designed as a fixed duration or a sequential test, then information on time to failure is desired, but may not be crucial, so that frequent interim performance tests may be sufficient during the tests or between individual tests in the test sequence. A reliability test schedule shall be utilized to define initial, midpoint(s), and endpoint conditions, requirements, and timing.

The test criteria list for these parts is defined in 3.4.4. The test criteria data from the functional test shall define nominal and endpoint values (if necessary) that meet the specification, for each function and each probe/monitor point. The supplier shall provide a spreadsheet of all test criteria data for each performance test to GM Engineering:

Failure to meet any of the functional tests shall be considered a failure for the speaker assembly. All abnormalities shall be reported within 24 h with a formalized report to the appropriate GM Engineering Center.

Corrective action shall follow with Five Phase Reporting.

3.4.3.1 The Functional/Parametric Tests Shall:

- a. Validate functionality by monitoring and recording that all outputs are in the correct state for a given set of inputs and timing conditions.
- b. Validate parametrics by monitoring and recording the specific voltage, current, and timing levels for all inputs and outputs and ensuring that these levels meet specification requirements.
- c. Selected parameters shall be statistically analyzed to evaluate whether build variations result in an acceptable degree of performance variation across the sample set. The distribution of the measured values shall not result in a skewed distribution stacked up against a tolerance limit.
- d. Selected comparisons shall be made between parametric measurements made on the Electrical/Electronic (E/E) devices when new, prior to testing, and when the DUTs complete the test sequences. Comparisons to the original measurements, individually and as a group statistically, shall be made to identify and quantify any performance degradation. If degradation limits are not specified in the CTS, the supplier and the GM Release engineer shall collaborate to define the degradation acceptance/failure criteria.
- e. DUTs shall have the following recovery time prior to Functional/Parametric measurements:
 1. 24 h minimum for Water, Humidity and Salt Fog tests
 2. 8 h minimum for Temperature tests
 3. Recover time not required for mechanical

3.4.3.2 The Continuous Monitoring Tests shall: (Refer to 6.1.1 "Operating Type 3.2".)

- a. Validate functionality, while the parts are exposed to the test environment, by continuously monitoring and recording exceptions to all outputs (both hardware and on vehicle communications) not being in the correct state for a given set of inputs and timing conditions. This can be performed by sampling. The sampling rate shall be reviewed with and approved by GM Engineering.
- b. All DUT inputs/outputs (including on vehicle communications) shall be continuously cycled and monitored for proper functional operation over all applicable power modes and battery voltages.
- c. The input/output cycling and monitoring shall be automatic for detecting any nonconformance; thereby, not requiring human intervention or observation at any time during the testing.
- d. The input/output cycling and monitoring should be automatic for recording a nonconformance to specification requirement issue. This may be visual or audible.

3.4.4 Test Criteria.**3.4.4.1 Functional/Parametric Checks.** Functional checks of speakers will consist of:

- **Resonant Frequency** – Reference GMW14833 Speaker Performance Test Specification, section titled Resonant Frequency and Impedance Measurement
- **Nominal Impedance** – Reference GMW14833 Speaker Performance Test Specification, section titled Nominal Impedance
- **Frequency Response** – Reference GMW14833 Speaker Performance Test Specification, section titled Frequency Response. Only on-axis measurements are required for pretest and posttest validation comparisons
- **Sensitivity** – Reference GMW14833 Speaker Performance Test Specification, section titled **Sensitivity**
- **Extraneous Noise** – Reference GMW14833 Speaker Performance Test Specification, section titled Extraneous Noise
- **Visual Inspection** – Reference 3.4.5

3.4.4.2 Continuous Monitoring Parameters. Speakers under test with continuous monitoring will be checked for continuity.

3.4.5 Device Open Up and Visual Inspection. Device Open Up and Inspection shall be performed as indicated in the Test Flow and Criteria List. Device Open Up and Visual Inspection shall consist of, but not be limited to, the following items. Device Open Up and Inspection shall be part of the agreed test plan prior to the start of testing. Failures for Device Open Up shall be decided by GM Validation, GM Release Engineer and the Supplier.

- Coil rubbing
- Gap contaminants
- Tinsel wire routing integrity
- Eyelet solder integrity
- Cone separation
- Cone, spider, surround deterioration
- Delamination
- Corrosion
- Abnormal wear
- Other unusual wear or observations determined by the GM Validation or Design Engineer

3.4.6 Test Discrepancies or Non-Conformance. All non-conforming parts shall be analyzed using a five (5) phase evaluation and answer process. A complete documented response, in a format shown as follows, shall be presented to the Platform/Program Validation Engineer.

a. Analysis Findings

- What is learned from the incident at component, assembly, and vehicle levels?
- Measures taken to search for the root cause. What steps were taken to proceed with the investigation?

b. Root Cause

- Ultimate root cause of the incident.

c. Immediate Fix

- What will be done to quarantine and correct contaminated stock?

d. Irreversible Corrective Action

- To prevent the incident from ever occurring again
- Traceable document (engineering change, process change, etc.)
- Projected date of implementation

e. Planned Action Verification

- Verification that irreversible corrective action works

In case of reliability/life testing, the non-conformances or test failures shall be addressed in two possible manners:

- If the test is reliability growth/demonstration type, the failures shall be investigated for the root cause and the test unit, if repairable, can be repaired and returned into test. The further testing or analysis shall determine whether the design or process change, if concluded necessary, is an effective improvement, and the scoring shall be done in accordance with reliability growth methodology
- If the test is a fixed duration or a sequential test, the failure shall be investigated, the failed unit can be repaired and returned into the test, or a new DUT can replace the failed unit. The data analysis shall then be done in accordance with the appropriate test methodology with the assumption of Poisson failure distribution. Each repetitive failure mode, when scored relevant, shall be included into the reliability estimate

3.4.7 Dimensional Test. Test per GMW3172 Dimensional Check. The Dimensional Test shall be performed at room ambient temperature where specified in the Validation Test Flow paragraph. All dimensional and physical requirements, including labels, on the GM released part drawing shall be validated and documented unless indicated otherwise by GM Engineering. Any Dimensional Test results that do not meet part drawing requirements shall be considered a validation nonconformance issue.

This procedure shall be performed on three (3) samples as a baseline after the Initial Conditioning and Performance tests, at T_{room} only: Three units in Leg 1.

This procedure shall be performed again on the same three (3) samples after High Temperature Storage and after Humidity, at T_{room} only.

This procedure shall be performed on the using samples defined in the Validation Test Flow Figure A1. If this is a stand-alone activity, then 2 h of high temperature storage testing shall be executed followed by dimensional test. All dimensions affecting the vehicle interface shall be included, e.g., mounting points, header connectors, external dimensions, etc.

3.4.8 Mechanical Simulations. The DUTs shall be assembled to an appropriately constructed fixture that simulates in-vehicle mounting and attitude. Special consideration shall be given to extraordinary attachments, loads, restraints, and clearances that would exist in the vehicle.

3.4.9 Electrical Connections. The DUTs shall be terminated with production intent connectors and all harness side mating connectors, terminals and wiring even if unpowered for testing.

3.5 Data. See various paragraphs.

3.6 Safety.

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

3.7 Documentation. Samples of components or material released to this standard shall be tested for conformity with the requirements of this standard and approved by the responsible GM Department prior to the start of delivery of production level components or materials.

Any change to the component or material, e.g., design, function, properties, manufacturing process and/or location of manufacture requires a new release of the product. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release.

If not otherwise agreed to, the entire verification test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product. In some cases, a shorter test can be agreed to between the responsible GM department and the supplier.

3.7.1 Test Results. All test results shall be included in a test report. This report shall be delivered to the responsible GM department. All running records of data collection shall be retained and made available to GM if requested. The test report shall be on standard size paper. The report shall contain the test phase (DV, PV) section number, test name, test leg, sample number and result (Pass/Fail). Any failures shall be reported to the responsible GM department immediately.

3.7.2 Deviations from Test Procedure. Deviations from the requirements of the test procedures shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports etc.

3.8 Reliability Requirements.

3.8.1 Reliability Demonstration. At the Engineering Technical Review, the supplier is required to present for approval a product assurance demonstration that includes statistically significant component life reliability demonstration analysis and/or testing performed in a combined mixed key environment or, if all the mixed key environments cannot be achieved in the laboratory, in an environmental sequence that would maximally approximate real life environmental exposure. Examples of such testing are One Life Success Test of Relevant Quantities, Test to Failure, Accelerated Life Test(s), and similar quantitative reliability demonstration type testing where reliability of the tested product can be calculated from the test. Reference GMW3172.

The speaker shall demonstrate the lifetime (T) reliability requirement (R(T)) in Table 2. The reliability number shall be demonstrated at a 50% confidence level. The tests shall be designed to demonstrate required reliability for the following usage profile and requirements: 241 402 km (150 000 mi) during the ten year life period.

- Average usage duration 2 h per day, a total of 7300 h for the life period
- On/Off cycling, eight (8) times per day
- Average number of door slams: eight (8) times per day
- The supplier shall demonstrate that the design meets the reliability requirement by way of success testing, accelerated life testing, by way of intermixed key environments where the appropriate reliability test data analysis, (Non-Homogenous Poisson calculation of failure intensity for the reliability growth type tests, or Poisson for the fixed duration or sequential type tests) including stress/load criteria, shall be performed. Any changes to materials or parts shall require revalidation that is designed to prove that change of materials or parts has not compromised reliability. This validation may be done by test or by detailed and defensible engineering or reliability analysis.

Table 2: Reliability

Speaker Minimum Required Lifetime Reliability in %	Test Sample Size
97.5	Fixed duration or sequential reliability demonstration tests: In accordance with the binomial distribution for the expected number of test failures to guarantee 50% confidence using: $\gamma(n) = 1 - \sum_{k=0}^r \frac{n!}{k!(n-k)!} \cdot [1 - R(T)]^k \cdot [R(T)]^{n-k} = 0.5$ Where γ = Confidence n = Sample size $R(T)$ = Reliability required to be demonstrated r = Expected number of test failures
	Reliability Growth Test:
	$R(T, n) = \exp \left[-\frac{r}{n \cdot T_T} \cdot \frac{\chi^2_{1+\gamma, (2 \cdot r+2)}}{2 \cdot r} \cdot (1 - \alpha) \cdot t_{ON} \right] \cdot \exp \left[-0.1 \cdot \frac{r}{n \cdot T_T} \cdot \frac{\chi^2_{1+\gamma, (2 \cdot r+2)}}{2 \cdot r} \cdot (1 - \alpha) \cdot t_{OFF} \right]$
	Where:
	T_T = calculated overall test duration – non-accelerated
	α = growth rate
	r = expected number of test failures
	n = sample size
N = 14	Note: n determined for the required reliability when $R(T, n)$ plotted as a function of n.

3.8.2 Design Reliability Estimates (Projections, Predictions, and Assessments). Design reliability performance estimates (i.e., $R(T)$) shall be determined. The estimates shall be presented and reviewed during design reviews. The estimates shall be updated for each design review to reflect reliability impact of test results or design revisions. Reliability improvement shall be plotted in accordance with reliability growth methods in design phase as shown in IEC 61014 and IEC 61164.

Reliability Prediction Models are methods that take into account the historical performance of the simplest individual devices or materials that make up an assembly (i.e., component) their respective failure modes that impact product reliability and how these elements perform under various levels of stress. Reference GMW3172. Information on reliability of components or assemblies shall be obtained from reliable sources such as manufacturers' life test data or established components reliability database sources for electronic components, and for mechanical components from the manufacturer's test data, strength/load analysis or Finite Element

Analysis (FEA). Reliability estimate/prediction shall be done for the given operational profile and the average environmental and operational stresses the component is expected to encounter during its life.

Reliability prediction for the subsystem and/or component shall be completed and performed according to platform/program timing requirements. An update and reissue is also required for any component changes after the original prediction has started.

Reliability prediction shall be completed before start of production.

3.9 Physical Subsystem and Component Failure Mode and Effect Analysis. A Failure Mode and Effects Analysis (FMEA) whether performed in a standard FMEA manner (tabular) or utilizing Fault Tree Analysis (FTA) shall emphasize reducing, eliminating, mitigating component potential failure modes, performance faults and prevention of vehicle/occupant safety related issues for the full product (component) usage life. Potential failure modes to be analyzed shall include as a minimum: all input and output circuits, circuits shorted to ground and probability of survival to lifetime usage and automotive interior environment exposure stresses. Process FMEA shall emphasize preventing faults or damage during component manufacturing/assembly handling and shipping transportation.

A physical subsystem FMEA or FTA will be performed on a vehicle by platform/program engineering. The supplier on the component will perform a physical component FMEA/FTA. Inputs and outputs will be physically shorted to ground or open circuit on a vehicle or component (as appropriate) to confirm the system FMEA results. Platform/program engineering may request that the supplier participate in the physical subsystem FMEA.

3.10 Design Cycle Requirements. Speaker Component Validation is a multilevel matrix requiring analysis, testing, inspection or other activities. The subsystem validation consists of Reliability estimates (e.g., Reliability Block Diagram (RBD), or FTA with the parts reliability information from parts databases or vendor life test results, and for mechanical parts, from mechanical engineering stress/strength or finite element analysis), FMEA, of Design Failure Mode and Effects Analysis (DFMEA) and production Process and Failure Mode and Effects Analysis (PFMEA), and reliability validation or demonstration testing. Design FMEAs may be required at different phases of the design cycle, four (4) Phase Vehicle Development Process (VDP). Each of these (analyses and/or tests) may be performed at a vehicle or at a component, level.

Analytical results of reliability estimates, when detailed and defensibly accurate, may be a substitute for reliability testing. Also, reliability demonstration test may be done in lieu of a complex reliability analysis. The optimal deliverables would include both, analytical estimates and the demonstration test results with the description of the test methodology that was applied in reliability demonstration.

4 Requirements and Procedure

4.1 General. The qualification and validation requirements specified herein shall be conducted using one or more of the validation methods defined as follows:

Test: Verifying that a specification requirement is met by; thoroughly exercising the item being validated under specified conditions in accordance with a test procedure; collecting quantitative data via test instrumentation; reducing and analyzing the collected data; and, comparing the results to the specified requirement.

Analysis: Verifying that a specification requirement is met by technical or mathematical evaluation of equations, algorithms, recorded data, charts, graphs, circuit diagrams, and representative data; and/or simulation of the item being validated using a mathematical representation (i.e., mathematical models, algorithms, or equations).

Inspection: Verifying that a specification is met by the physical examination of the item being validated and comparing the observed physical characteristics with the specifications and/or drawings.

Demonstration: Verifying that a specification requirement is met by exercising the item being validated, under specified conditions in accordance with a test procedure, observing the results, and comparing the results to the specified requirements. The collection of test data via test instrumentation is normally not required.

Validation: The formal process of confirming, through analysis, demonstrations, inspections, and/or tests, that a product meets its requirements

4.2 Validation Cross Reference Index (VCRI) Table. The VCRI table shall be a part of the CTS and/or SSTs and shall map the validation and requirements to each other. Each technical requirement shall map validation procedure(s) necessary to completely validate the associated requirement.

4.3 Mechanical Speaker Characteristics Validation. All test samples shall be interfaced with the respective mating connector. Before and after each test, physically shake the components and verify that no rattle can be