GM	WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW17010

Mechanical Shock and Vibration Durability Test - Thermal Under Hood Procedure 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 standard shall provide the testing requirements of various forms of heat exchanger(s) using a common global mechanical shock and mechanical vibration profile.

1.2 Applicability. This standard in conjunction with other GM standards that complete the heat exchanger high life stress tests using the requirements of proving the specified level of reliability and confidence level outlined in the Analysis/Development/Validation (A/D/V) plan and permit the part to be validated for use within GM globally.

1.3 Remarks. This specification is mainly for Heating, Ventilation and Air Conditioning (HVAC) and Powertrain Cooling (PTC) components that are mounted to the body with rubber isolation, such as heat exchangers or Condenser Radiator Fan Module (CRFM). Examples are Charged Air Coolers (CAC), refrigerant condensers, coolant radiators, external engine oil or transmission oil coolers, combination coolers and fan shrouds. This specification or portions thereof can also be used for other body mounted components without rubber isolation like brackets, hoses, transmission oil lines and cables, coolant reservoirs, surge tanks, and clips with prior GM engineering approval. In addition, this specification covers engine powertrain mounted components that directly attach to the engine. Examples are brackets, hoses, lines and cables, and small CAC. Lastly, this specification covers engine mounted compressor Air Conditioning (A/C) lines. This GM standard shall not replace vibration requirements for validating any electrical and electronic components - use GMW3172 for validating those components.

2 References

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

2.1 External Standards/Specifications.

SAE J639

2.2 GM Standards/Specifications.

GMW3059	GMW3425	GMW15920
GMW3172	GMW15758	

2.3 Additional References.

- Design Review Based on Test Results (DRBTR).
- Established Roads program.
- GM1829 - GM Analysis/Development/Validation Plan and Report (ADVP&R).
- Release Drawing.
- Test report.
- Vehicle Technical Specification (VTS).

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3 Test Preparation and Evaluation

3.1 Resources.

3.1.1 Facilities. Test facilities according to the test specifications and standards listed.

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. It is preferred that single axis vibration equipment be used to minimize test time required. If tri-axial equipment is desired, contact the GM Validation Engineer for an alternate profile. Tri-axial equipment will result in a significantly longer overall test duration. The control accelerometer shall be located on the fixture, near one of the lower mounting bushings. A response accelerometer shall be mounted on the fixture, near one of the upper mounting bushings. At least one tri-axial response accelerometer shall be mounted on the test piece at the midpoint between the two rubber isolators farthest in the Z direction from the control accelerometer. For a CRFM, this is at the middle of the upper radiator core cover.

3.1.3 Test Vehicle/Test Piece. A Finite Element Analysis (FEA) of the planned vibration test fixture shall be performed to determine any resonant frequencies in each of the three axes over the test frequency spectrum (CRFM = 3 Hz to 250 Hz, Engine Mounted = 7 Hz to 2000 Hz). The results shall be reviewed with the GM Validation Engineer before the test can begin. The results of this FEA shall be included in the test report.

3.1.4 Test Time. Not applicable.

3.1.5 Test Required Information. The performance measurements and durability test results shall be summarized and reported to GM on the supplier GM1829 Analysis/Development/Validation Plan and Report (ADVP&R) for the component or components being tested. Full test reports shall be available for viewing by GM personnel per GMW15920. If there is a breakage on test, GM must be informed within 24 h.

3.1.6 Personnel/Skills. The personnel and skill requirements are the responsibility of the supplier.

3.2 Preparation. There must be 15 mm of static clearance between the test fixture and any part of the test specimen at start of test. No components shall be added to the test fixture after the test has begun.

3.2.1 Fixture Resonance.

3.2.1.1 Fixture Design Verification. This test is done well ahead of the start of test. A frequency response sweep of the empty/unloaded vibration test fixture shall be performed to determine the frequency response curve of the vibration test fixture in each of the three axes. The input for the sweep shall be a sinusoidal 1G input. Time to sweep shall be approximately one (1) minute per 100 Hz. Passing criteria can be found in Table 1.

If the criteria in Table 1 cannot be met, the supplier shall make at least one attempt to improve the fixture performance before discussing the results with the GM Validation Engineer before testing begins. The GM Validation Engineer will decide if further improvements are necessary, or will approve the fixture performance as it exists.

The results of the frequency response sweeps shall be included in the test report. Any deviations from the specified vibration profile must be documented in the test report, including the GM Validation Engineer's signature.

3.2.1.2 Energy Profile Maximum Frequency Selection. This test is done just before the test starts, and is repeated as needed during the test (for diagnostic purposes). A frequency response sweep of the loaded (includes CRFM) vibration test fixture shall be performed to determine the frequency response curve of the vibration test fixture with CRFM in each of the three axes. The input for the sweep shall be a sinusoidal 1G input. Time to sweep shall be approximately one (1) minute per 100 Hz. Passing criteria can be found in Table 1.

If the criteria in Table 1 cannot be met, the maximum frequency that meets the criteria shall be used as the maximum test frequency. The GM Validation Engineer must approve this reduction before testing begins.

If the vibration equipment being used is not capable of 3 Hz due to stroke limitation, a deviation will be approved based on the capabilities of the test equipment, up to a maximum of 10 Hz.

Note: This exception is typically due to a machine that does not have sufficient force or sufficient stroke to move the combined mass of the fixture and samples at the lowest test frequencies. Any value between 3 Hz and 10 Hz is acceptable, based on the maximum capability of the machine for the combined mass of the fixture and samples.

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The results of the frequency response sweeps shall be included in the test report. Any deviations from the specified vibration profile must be documented in the test report, including the GM Validation Engineer's signature.

3.2.2 Energy Transmission Tests. Before testing, perform the following steps:

a. Set up parts as per vehicle configuration, including brackets and isolators. If Design Validation/Process Validation (DV/PV) brackets are not available, the bracket geometry must be represented, specifically regarding clearance to the part being tested, and the interface to the isolator. See Test Conditions in 3.3.2.

b. Place a tri-axial accelerometer on the middle of the upper radiator core cover.

Table 1: Energy Profile Deviation Allowed

	% Deviation Allowed from Input Energy (%)					
Frequency Range (Hz)	X to 10	10 to 100	100 to 250	250 to 500	500 to 1000	1000 to 2000
Body Mounted, Rubber Isolated	50	50	100	N/A	N/A	N/A
Body Mounted, Non-Isolated	50	50	100	N/A	N/A	N/A
Engine Mounted - A/C Compressor Lines	50	50	100	100	N/A	N/A
Engine Mounted - Other	50	50	100	100	100	100

N/A Not applicable.

3.2.2.1 Natural Frequency Test.

- Perform a first order frequency response sweep with an input of 1.0G. Record four (4) channels of data (input direction, X output, Y output, and Z output). Plot the four (4) channels with acceleration (G) vs. frequency 0 Hz to 120 Hz. Also plot the four (4) channels with acceleration (G) versus time (ms). On the acceleration versus time plot, plot input frequency (Hz) versus time (ms) on a secondary Y axis.

3.2.2.2 Isolation Characterization Test (ICT). This section (3.2.2.2) applies to any part that is rubber isolated, the primary example being the CRFM.

- Input a 25G input, half-sine, 10 ms duration pulse, in the input direction.
- Filter the output with a low pass filter at a frequency of 200 Hz. Record four (4) channels of data (input direction, X output, Y output, and Z output). Plot the data with acceleration (G) versus time (ms). Set the graph's Y axis maximum/minimum to the maximum/minimum values of the data (do not let Excel (a spreadsheet program) add a little).
- If the data does not comply with the following two statements, prepare a short test report with all the data and inform the GM System Validation Engineer (SVE). A review of the test setup will occur and a design change to the isolator system may occur.
  1. The ratio of the absolute values of the positive and negative peak values shall be between 0.8 and 1.2.
  2. The absolute value of the positive and the negative peak values are each < 50G.

Note: Hard contact conditions create high G-force responses. These conditions must be identified and eliminated before running any test legs. Painting of parts may be required to identify locations of contact. The supplier is responsible for part to part contact within the CRFM. If the contact occurs between the CRFM and "body structure" (upper/lower brackets, not the fixture), then contact GM for resolution.

3.2.3 Body Mounted, Rubber Isolated. The primary example for this category is the CRFM, but other components may also apply.

3.2.4 Engine Mounted. This category applies to any parts mounted to the engine other than A/C Compressor Lines.

3.2.5 Engine Mounted - A/C Compressor Lines. This category only applies to A/C Compressor Lines.

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3.2.6 Body Mounted, Non-Isolated. The primary example for this category is the Surge Tank Bottle, but other components may also apply**.**

3.3 Conditions.

3.3.1 Environmental Conditions. Unless other conditions are specified for a procedure, these tests shall be run at (17 to 25) °C and that temperature is to be recorded.

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. See the GM Validation Engineer. Provide a letter signed by both the supplier and the GM Validation Engineer before the start of the vibration test. This letter shall be included in the final test report. Components shall be installed in vehicle orientation on the shaker. If two components are mounted on one fixture, both components shall face in the same direction. If the orientation may be different from vehicle to vehicle, use the orientation which will provide the worst case loads.

In the specific case of a CRFM module, design representative plumbing is not required. The following boundary conditions apply:

a. Coolant to Air heat exchangers shall be capped using a straight piece of generic bulk hose with an aluminum plug. The length of the hose shall be three (3) times (± 20%) the diameter of the port. The aluminum plug shall be a cylinder equal in diameter to the Inside Diameter (ID) of the bulk hose, and the thickness shall be half (± 20%) the diameter. The plug shall provide the capability to pressurize the heat exchanger. The heat exchanger shall be filled with water, and pressurized to 103.5 kPa.

b. Refrigerant to Air heat exchangers shall be capped using a straight piece of metal tubing, 150 mm long, with a design representative end form at the heat exchanger interface. The tube can be pinched and welded for sealing at the free end. The heat exchanger shall be pressurized with air to 207 kPa.

c. Oil to Air heat exchangers shall be capped using a straight piece of metal tubing, 150 mm long, with a design representative end form at the heat exchanger interface. The tube can be pinched and welded for sealing at the free end. The heat exchanger shall be filled with the appropriate oil, and pressurized to 207 kPa.

d. Air to air heat exchangers (e.g., CAC) shall be capped using a CAC duct equal in length to three (3) times (± 20%) the port diameter. The interface of the duct to the heat exchanger shall be design representative. The duct shall be capped, and the heat exchanger pressurized to 207 kPa.

e. The upper and lower fixture brackets, that the isolators interface with, shall be design representative of the vehicle in regards to geometry and surface finish. Prototype or production sheet metal from the vehicle build is not required.

f. The electric fan shall be cycled throughout the test. The rate is one (1) minute on at 80% power, one (1) minute off.

g. All fasteners used shall be GM Fasteners, or be design representative of the vehicle with regards to thread size, thread engagement and washer/bolt-head diameter. All fasteners shall be installed to the lower tolerance limit of the torque specification.

Boundary conditions not otherwise listed, or for components other than the CRFM module, shall be agreed with the GM Validation Engineer and documented in the validation test report.

3.3.2.1 Test Time. Approximately eight (8) days per Reliability Evaluation Point (REP) for a Developing Roads Profile.

3.3.2.2 Mechanical Shock/Pothole. The following mechanical shock tests are required for body mounted components (both rubber isolated and non-rubber isolated) including the Condenser Radiator Fan Module (CRFM). Mechanical shock testing is applicable only in the first life of the REP; it is not applicable during the second life. Directional considerations follow Appendix A, Figure A1. Follow each mechanical shock input cycle with a rest period of 3 s to 5 s (no input excitation) in order to allow the rebound oscillations to settle.

a. **Vehicle Pothole - Unibody (see Appendix A, Table A1).** Refer to Table A1 for loads and direction of mechanical shock.

b. **Vehicle Pothole - Body on Frame (see Appendix A, Table A2).** Refer to Table A2 for loads and direction of mechanical shock.

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3.3.2.3 Random Vibration - Body Mounted. The following vibration tests are required for body mounted components that are rubber isolated including Condenser Radiator Fan Module (CRFM). This is a reliability test.

a. **Car Vibration for Sprung Masses (see Appendix B, Figure B1, Table B1, Table B2 and Table B3).** Simulation shall be on a single axis shaker. If a tri-axis shaker is desired by the supplier, the GM Validation Engineer will provide the required test profile changes.

b. **Truck/Sport Utility Vehicle (SUV) Vibration for Sprung Masses (see Appendix C, Figure C1, Table C1, Table C2 and Table C3).** Simulation shall be on a single axis shaker. If a tri-axis shaker is desired by the supplier, the GM Validation Engineer will provide the required test profile changes.

3.3.2.4 Random Vibration - Engine Mounted. The following vibration tests are required for engine mounted components depending upon the number of engine cylinders respectively. This is a reliability test.

a. **Unibody Vibration for Engine Components (see Appendix D, Figure D1, Table D1 - Four (4) Cylinder, Table D2 - Six (6) Cylinder, Table D3 - Eight (8) Cylinder).** Simulation shall be on a single axis shaker. If a tri-axis shaker is desired by the supplier, the GM Validation Engineer will provide the required test profile changes.

b. **Body on Frame Vibration for Engine Components (see Appendix E, Figure E1, Table E1 - Four (4) Cylinder, Table E2 - Six (6) Cylinder, Table E3 - Eight (8) Cylinder).** Simulation shall be on a single axis shaker. If a tri-axis shaker is desired by the supplier, the GM Validation Engineer will provide the required test profile changes.

3.3.2.5 Engine Mounted Compressor A/C Lines - Natural Frequency Shaker Test. The purpose of the test is to shake the assembly of compressor and attached A/C lines in all three axis with a specified natural frequency according to a matching acceleration amplitude found in Appendix F, Table F1, Table F2, Table F3, Table F4 and Table F5 respectively, for 10 000 000 cycles (each axis). Only natural frequencies found up to 500 Hz maximum shall be tested. These modes can be found using the procedure in Appendix F see Appendix F, F2.5, F2.8, and F2.9. This is an independent test for engine mounted compressor A/C lines only, with one part sample only. The sections; 3.2.2, 3.3.2.1, 3.3.2.2, 3.3.2.3, 3.3.2.4, 3.4, 3.5, 4.2, 4.2.1, 4.2.2., 4.2.7, 4.2.7.1 and 4.2.7.2 shall not be observed. See Appendix F for step by step instructions on test setup and how to run the test.

3.3.2.6 Axis Shaker Input Profile Selection. Select the appropriate axis shaker input file based on the type of engine (gas or diesel) and the number of cylinders that the component is being mounted on. If more than one engine is used, select the four (4) cylinder engine shaker input profile that represents the most severe of the applications. For example, if the component mounts to a four (4) cylinder gas and an eight (8) cylinder diesel engine, use the four (4) cylinder diesel shaker input profile. However if the component mounts to a four (4) cylinder gas and an eight (8) cylinder gas engine, use the four (4) cylinder gas shaker input profile.

All profile(s) include safety margin. As an alternative, it is permitted and encouraged to use specific engine measurements when available (for example: from engine dynamometer setup) and increase amplitude by 50% for safety margin. Contact GM engineering to understand if this data is available prior to testing.

a. **All Engines X, Y, and Z (except four (4) Cylinders)** - Use the shaker input profile found in Appendix F, Table F1.

b. **Four (4) Cylinder Gas X and Y Axis** - Use the Shaker Input profile found in Appendix F, Table F2.

c. **Four (4) Cylinder Gas Z Axis** - Use the Shaker Input profile found in Appendix F, Table F3.

d. **Four (4) Cylinder Diesel X and Y Axis** - Use the Shaker Input profile found in Appendix F, Table F4.

e. **Four (4) Cylinder Diesel Z Axis** - Use the Shaker Input profile found in Appendix F, Table F5.

3.3.2.7 Random Vibration - Body Mounted, Non-Rubber Isolated. The following vibration tests are required for body mounted components that are not rubber isolated including coolant bottles and surge tanks. This is a reliability test.

a. Vibration for Sprung Masses (see Appendix G, Figure G1, Table G1, Table G2 and Table G3). Simulation shall be on a single axis shaker.

3.4 Instructions. This GM standard will simulate mechanical shocks and vibrations for 240 000 km (150 000 mi). If vehicle requirements are for 320 000 km (200 000 mi) multiply the time duration by 1.33.

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Example: Using the 48 h/axis random vibration test duration, testing will be multiplied by 1.33, giving a new random vibration test duration of 64 h/axis. Also, the pothole shocks (400/axis) will be multiplied by 1.33, giving a new pothole shock quantity of 533/axis.

It is the responsibility of the supplier to confirm with the GM Validation Engineer the duration of testing required.

3.5 Data. The detailed report must include the data required in 3.1.3, 3.1.5, 3.2.1.1, 3.2.1.2, 3.2.2.1, 3.2.2.2, 3.3.1, 3.3.2, and 4.1.6. Visual monitoring for part degradation throughout the test is required. Inspections shall record any degradation, e.g., change to component shape, condition, location or orientation. Also, results of post-test inspections for each component must be included in the report.

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. Test results shall be reported with the respective component General Motors Worldwide (GMW) standard and GM1829. See 3.5.

3.7.2 Conformity. 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.

4 Requirements and Procedure

4.1 General.

4.1.1 Observance of Specification. Not applicable.

4.1.2 Installation Position. Components shall be installed in vehicle position.

4.1.3 Validation Phase Definitions. Reference GMW15758 (A/D/V Process Development and Validation Terminology) for the definitions of Design Validation, Product Validation, and Post Validation Audit.

4.1.4 Test Samples. Reference GMW15758 for explanations of how parts for Design Validation, Product Validation, and Post Validation Audit shall be produced and selected. Test sample dimensions and materials must be within specification.

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

4.1.6 Component Failure. After each test, the component(s), for example, the radiator, condenser, charged air cooler and the electric cooling fan and shroud assembly shall be able to function 100% without leaking or with reduced fan power. Failure is defined as, but not limited to, the loss of function, loss of structure, unacceptable performance degradation, and nonconformance of the component as stated in this specification and the specification for the component being tested. No fractures shall appear in any mounting brackets. No tears shall appear in any isolators.

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4.2 Endurance Test Requirements. These tests are designed to demonstrate the component reliability. Endurance testing may be conducted using either Test to Failure, 4.2.1 or Success Testing, 4.2.2. Test to Failure (TTF) is always the preferred method.

The REP for any Unibody or Body on Frame program represents 240 000 km (150 000 mi). It is the responsibility of the supplier to confirm the REP for the test samples. See 3.4.

4.2.1 Test to Failure. See 4.1.6 for failure definition. Use of Weibull analysis is required to determine the reliability.

Note: The required number of test samples may be negotiable (considering test equipment limitations, test sample physical size, test duration, etc.) Weibull slope values available from previous failure testing may be considered as a way to reduce the sample size and/or test duration. Reduction of sample size shall not cause demonstration of the reliability requirement to be unfulfilled. In no case shall the test sample quantity be less than four (4) samples. In no case shall the Weibull slope be > 3.0 (even with previous failure data). In the absence of prior TTF testing, the default slope shall be 2.25 for component testing, and 1.8 for sub-system testing, but may be reduced by the GM Validation Engineer for new designs or suppliers.

Note: For Test to Failure:

a. If any failure occurs in the 1st life of customer usage (1st REP), stop the entire test. Do a Design Review Based on Test Results (DRBTR), perform root cause analysis. If, as determined necessary by root cause analysis, redesign the part or product; start testing all over again.

b. Upon failure after the 1st life, inform the GM Validation Engineer, continue to the test plan, plot Weibull slope and calculate reliability demonstrated.

c. If no failures by the completion of the required reliability demonstration, remove half of the samples from test stand and do the functional tests followed by DRBTR.

d. Continue test to failure with the remaining samples (consider using stepped stress methods to induce failure, as approved by the GM Validation Engineer) and do the functional tests followed by DRBTR to analyze failed samples.

4.2.2 Success Testing. Refer to Table 2 for success test.

Table 2: Number of Samples Required for Endurance Tests

Minimum Sample Size Required				
Test Type	**Reliability Requirement**	**Quantity of REPs (lives)**	**Slope (beta)**	**Success Testing (samples)**
Component	R99 C50	3.0	2.25	6
Sub-system	R95 C50	2.0	1.8	4

Note: The slope values listed may be reduced by the GM Validation Engineer for new design or new suppliers.

Note: For Success Testing:

a. See 4.1.6 for failure definition. If any failure occurs in the 1st life of customer usage, stop the entire test. Do a Design Review Based on Test Results (DRBTR), perform root cause analysis. If, as determined necessary by root cause analysis, redesign the part or product; start testing all over again.

b. Upon failure after the 1st life, plot Weibull slope and calculate reliability demonstrated.

4.2.3 Electrical Data. Components shall be operated as in the respective vehicle and per the corresponding General Motors Worldwide (GMW) standard.

4.2.4 Hydraulic Data. Components shall be filled and pressurized as in vehicle and per the corresponding GMW standard.

4.2.5 Ambient Conditions. Refer to 3.3.1.

4.2.6 Vibration Test. See Appendix B, Appendix C, Appendix D, Appendix E, Appendix F and Appendix G.

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4.2.7 Test Flow.

Perform the fixture setup confirmation tests in 3.2.1 and 3.2.2 for each of the three axes, independently. Perform the first life REP, and followed by the additional lives/REPs as needed.

Note: A Characterization Test shall be performed at 0%, 25%, 50%, 75%, and 100% of each test section (e.g., Pothole (+X) is one test section. Random Vibration (X) is another test section).

Note: One set of isolators is expected to last for a complete test leg (a through f (4.2.7.1 through 4.2.7.2) are six (6) separate legs) without replacement. If the output energy measured during any Characterization Test is beyond the allowed values (see 3.2.2.2), then the isolator is "worn out". The test shall be stopped, and a meeting with GM shall occur to determine next steps. Visual inspection shall not be used as the criteria for indicating that the isolator is "worn out".

Note: All fasteners shall be monitored for torque retention. Fasteners found to have lost torque retention, e.g., have backed-out, shall be reported immediately to GM Engineering. At the end of testing, all fasteners shall be measured for residual torque.

4.2.7.1 First (1st) Life REP.

a. Pothole (-Y) → Random Vibration (Y) → Change all rubber isolators.

b. Pothole (+X) → Random Vibration (X) → Change all rubber isolators.

c. Pothole (+Z) → Random Vibration (Z) → Change all rubber isolators.

4.2.7.2 Additional Lives/REPs.

d. Random Vibration (Y) → Change all rubber isolators.

e. Random Vibration (X) → Change all rubber isolators.

f. Random Vibration (Z) → Change all rubber isolators, if doing further REPs.

4.2.8 Compressor A/C Line Natural Frequency Shaker Test. See Appendix F for setup example and an example of establishing the natural frequency and acceleration.

4.2.9 Compressor A/C Line Test Flow.

4.2.9.1 Only one life required, test flow can be varied.

- Sinus Wave Vibration (Z), 10 000 000 cycles for each natural frequency found.
- Sinus Wave Vibration (X), 10 000 000 cycles for each natural frequency found.
- Sinus Wave Vibration (Y), 10 000 000 cycles for each natural frequency found.

4.3 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all of the potential 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 local, regional, state and national regulatory limitations prior to use. See SAE J639 for more information.

4.3.1 Caution. This specification refers to the usage of testing pressurized vessels. These tests shall be performed only by properly trained qualified personnel in using equipment capable of withstanding the pressures, temperatures and exposure of these tests with adequate safety margins. Standard laboratory safety precautions must be followed to prevent accidental bodily injury. All material shall be used in accordance with the manufacturer Material Safety Data Sheet (MSDS).

4.4 Deviations from This Standard. Deviations from the requirements of this standard shall have been agreed upon by the responsible GM Design Release Engineer and GM Validation Engineer and submitted into the GM database for historical and reference purposes (see 3.1.5). Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.5 Additional Requirements.

4.5.1 Changes. Any change to the component or material, i.e., design, function, properties, manufacturing process and/or location of any change or modification to the product/process and manufacture requires a new release of the product. This includes changes in Tier 1 sub-supplier chains. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification of the production product/process and

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to apply for a new release. If not otherwise agreed to, the entire DV/PV 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 Validation Engineer and the supplier.

4.5.2 Design Review Based on Failure Mode (DRBFM). Required for all changes, a DRBFM shall be conducted by the supplier for all product and process changes as described in 4.5.1. This process may also be used to determine applicability of surrogate data for specific DV and PV tests.

5 Provisions for Shipping

Not applicable.

6 Notes

6.1 Glossary.

Body on Frame: Typically a truck, a vehicle where the suspension is mounted to a frame separate from the body, and the CRFM is completely mounted to the body.

G: Unit of acceleration having magnitude equivalent to gravity, 9.81 m/s^2.

Unibody: Typically a car, a vehicle where the suspension is mounted directly to the body.

6.2 Acronyms, Abbreviations, and Symbols.

A/C	Air Conditioning
A/D/V	Analysis/Development/Validation
ADVP&R	Analysis/Development/Validation Plan and Report
CAC	Charged Air Coolers
CRFM	Condenser Radiator Fan Module
d	Displacement [mm] of dominant natural frequency
DFSS	Design for Six Sigma
DRBFM	Design Review Based on Failure Mode
DRBTR	Design Review Based on Test Results
DRE	Design Release Engineer
DV/PV	Design Validation/Process Validation
FEA	Finite Element Analysis
FREQ	Frequency
Freq.	Frequency
GMW	General Motors Worldwide
Grms	Root-Mean-Square Acceleration
GSSLT	Global Subsystem Leadership Team
HVAC	Heating, Ventilation and Air Conditioning
ICT	Isolation Characterization Test
ID	Inside Diameter
LVW	Loaded Vehicle Weight
MSDS	Material Safety Data Sheet
N/A	Not applicable
NOK	Not OK
Profil	Profile
PSD	Power Spectral Density

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