



## Global Self-Induced Gravel Chipping

### 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 test a vehicle for self-induced stone impact damage. Areas of the vehicle that are susceptible to stone impacts shall be identified and any changes that are needed to the styling or components shall flow into the development process at an early stage.

Four (4) testing options are available and described in the below document. Each individual testing option does not necessarily need to be performed. They can be executed on an as-needed basis. Below summarizes the four options:

**1.1.1 Total Vehicle Analytical Evaluation (math based).** The stone impingement performance of a vehicle is influenced by the geometry and impact angles that stone will impinge the vehicle with. To better understand the vehicle's performance prior to any physical properties being available, a math-based tool can be used to evaluate the studio surface. Modifications to the vehicle can then be made prior to a design freeze on the vehicle.

**1.1.2 Exterior Styling Concept Development (road based).** Stone impact damage to the lower exterior surfaces (fenders, quarter panels, doors, etc.,) can lead to customer complaints or, in extreme cases, to cosmetic corrosion and thus to loss of vehicle value. The development test, therefore, serves to influence the outer shape of the vehicle. (The test results shall be available before styling freeze.) For this test the outer skin of the susceptible stone impact areas is fitted to a mule vehicle to evaluate the stone impact behavior and potentially optimize the styling of the vehicle. These results shall be able to be used to prevent directly visible stone impact damage for customers.

**1.1.3 Underbody Development (Road Based).** The objective is to evaluate stone impact damage to the underbody structure or underbody components that could lead to cosmetic corrosion or functional issues.

**1.1.4 Total Vehicle Validation (Road Based).** During the validation test, a production produced vehicle or vehicle that is close to production representative is evaluated for the following:

**1.1.4.1** Exterior stone impact damage that is visible and may be objectionable to critical customers.

**1.1.4.2** Underbody stone impact damage that may lead to corrosion or functional issues.

**1.2 Applicability.** Passenger cars, light trucks, sport utility vehicles, minivans, etc. This test is not intended to be applied or correlated to medium duty vehicles.

**1.3 Remarks.** Many rural roads contain gravel or small stones that can be projected by a vehicle's tires or lofted as a result of the reaction force from the road surface as the vehicle/tire roll over the stones and cause chipping of the vehicle underbody, chassis components, and/or exterior lower body side panels.

This test procedure is limited to self-induced chipping which occurs in areas rear of the front and rear tires (including underbody, body side panels, etc.) It does not evaluate chipping to the front exterior body panels or components (i.e., hoods, fascias, bumper, windshield, etc.,) due to:

- Following another vehicle on gravel roads **or**
- Running into stones thrown by vehicles traveling in the opposite direction.

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## 2 References

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

### 2.1 External Standards/Specifications.

None

### 2.2 GM Standards/Specifications.

|              |          |          |          |
|--------------|----------|----------|----------|
| GMW8738 (ID) | GMW15291 | GMW15294 | GMW15975 |
| GMW14700     | GMW15292 | GMW15443 | GMW15981 |
| GMW15290     | GMW15293 | GMW15531 |          |

(ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

### 2.3 Additional References. Site specific driving instructions.

|            |            |            |          |
|------------|------------|------------|----------|
| DR.CA.1183 | DR.DH.DR-1 | DR.LL.6GMC | DR.MF.DG |
|------------|------------|------------|----------|

## 3 Resources

### 3.1 Facilities.

- a. Cruz Alta Proving Ground.
  - Gravel roads.
- b. Dudenhofen Proving Ground.
  - Dedicated gravel road.
- c. Guangde Proving Ground.
  - Antilock Brake System (ABS) Gravel roads.
  - Traction Control System (TCS) 8% Gravel Hill
  - Dedicated Gravel Road
- d. Lang Lang Proving Ground.
  - Gravel roads.
- e. Milford Proving Ground.
  - Dedicated gravel road facility (including dedicated gravel return road).
  - Level durability course (Heavy Vehicle Test Area (HVTa) – Military).

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

**3.1.2 Alternatives.** Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

### 3.2 Equipment.

**3.2.1 Math Based Analysis.** A Unigraphics (UG) with the Stone Chip Operator is required for the analysis.

**3.2.2 Road Based Analysis.** Some or all of the following may be needed to document results depending on test objective:

**3.2.2.1** Equipment to measure anti-chip coating and paint system thickness.

**3.2.2.2** Photographic chip rating scale GMW15290 through GMW15294. These scales provide Subjective Rating (SR) for typical vehicle chipping patterns and locations.

**3.2.2.3** Photographs relating a subjective rating to different levels of chipping to be used in rating test areas. These photographs are found in GMW14700 Chip Resistance of Coatings.

**3.2.2.4** Photographic equipment to document results.

**3.2.2.5** Wax plates, paint spray, linen strip, modeling clay (e.g., plasticine).

**3.2.2.6** Auxiliary materials for determination of tire contact surface width, trim height sheets.

### 3.3 Test Vehicle/Test Piece.

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**3.3.1 Math Based Analysis.** No physical properties are required. Only a UG model with the desired studio surface is required.

**3.3.2 Road Based Analysis.** Depending on test objective, any or all of the following may apply:

**3.3.2.1** Engineer should evaluate which tires should be installed, since tires and/or the vehicle options (i.e., moldings) available with these tires may affect test results. The wheel option with the most critical tire dimension (typically the largest wheel offering) and the most aggressive tread pattern shall be selected. The application to performance or personalization tires has to be decided per project. Tire inflation pressure and tire width patch shall be set appropriately. When performance comparisons between vehicles are planned, the tire type, size and amount of wear should be the same for all vehicles.

**3.3.2.2** The vehicle shall be ballasted to the appropriate level (e.g., Loaded Vehicle Weight (LVW), Gross Vehicle Weight (GVW), etc.)

**3.3.2.3** Engineer shall consider whether to install design-intent moldings, guards, or other protective components in the wheelhouse and gravel throw areas, depending on these components and their availability on a specific model or whether they are standard/optional equipment.

**3.3.2.4** The following sentence is applicable if a dedicated test vehicle has yet to be built. If the body panel performance is being evaluated, the vehicle paint system and any anti-chip coatings must be the design-intent thickness, material, processing, and location. Also, select contrasting colors of the paint layers (i.e., topcoat, primer, ELPO, etc.) to highlight chipping between these paint layers.

**3.3.2.5** Paint color can affect chip performance. When performance comparisons between vehicles are planned, the paint color for all vehicles should be the same. Worst-case colors have low binder-to-pigment ratios (e.g., red). Best-case colors have high binder-to-pigment ratios (e.g., white).

**3.3.2.6** If the lower body side panel performance is being evaluated, the vehicle doors and front fenders must be adjusted per the Master Process Documents (MPD) or design-intent. These door and fender adjustments affect the damage that gravel can do to the adjacent components. For example, a front fender located outboard of the front door will protect the leading vertical edge of the front door from gravel throw. Other examples of components are identified in the Stone Chip Avoidance Guideline GMW15290 through GMW15294 published by Corrosion Engineering at the Milford Proving Ground (PG). Record whether vehicle is set to nominal specifications or otherwise in test records.

**Note:** Vehicle shall be at nominal height.

**3.3.3 Exterior Styling Concept Development.** This test requires the following data and physical properties:

**3.3.3.1** Definition/level of styling (or studio) surface to be evaluated.

**3.3.3.2** Chassis dimensions including wheel/tire configuration, track widths, etc.

**3.3.3.3** Selection of a mule vehicle.

**3.3.3.4** Composite of the exterior surface of the vehicle to be applied to the above identified mule vehicle. This should be a negative model and stable ( $\approx 8$  mm thick) laminate. Wood or hard foam batten are glued to the inside of the laminate for fitting to the mule vehicle, and this is ground down to outer contour of the mule vehicle (shifted in Y direction parallel to the grid).

**3.3.3.5** Adjusting to the correct side wall/tire ratio can be accomplished by using shims **and**:

**3.3.3.6** A laminate contour grid shift in the Y direction.

**3.3.3.7** The track width difference between the mule vehicle and the new model.

**3.3.4 Underbody Development.** The following are needed:

**3.3.4.1** Suitable test panels or component test parts that are attached to a mule vehicle (A-B comparison).

**3.3.4.2** Vehicle with which underbody that complies with state of development and/or (e.g., integration prototype) testable components can be directly tested.

**3.3.5 Total Vehicle Validation.**

**3.3.5.1** Production intent vehicle including production materials, production processed ELPO, primer, and topcoat. The vehicle may also require underbody polyvinyl chloride (PVC) coating if such designed.

**3.4 Test Time.**

Calendar time: 1 d to 30 d

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Test time: 8 h to 90 h

Coordination time: 1 h to 40 h

**3.5 Test Required Information.** Not applicable.

**3.6 Personnel/Skills.**

**3.6.1 Math Based Analysis.**

**3.6.1.1** A skilled UG technician.

**3.6.2 Road Based Analysis.**

**3.6.2.1** A skilled photographer to take pictures of the evaluated areas is suggested due to the difficulty of taking clear, detailed pictures of chipping.

**3.6.2.2** A test driver skilled in the operation of a test vehicle on loose, gravel roads.

**3.6.2.3** A development engineer to coordinate the test and test properties.

## 4 Procedure

**4.1 Preparation.** The following is only applicable to the road based analysis. A suitable test vehicle shall be selected prior to test execution per 3.3.2.

- Perform pre-test inspections and measurements as requested by engineer to establish initial vehicle condition. Vehicle must be clean. These inspections and measurements may include:

**4.1.1** Paint and anti-chip thickness measurements.

**4.1.2** Documentation of pre-test damage using GMW15290, GMW15291, GMW15292, GMW15293, GMW15294 or chipping rating scale of GMW14700.

**4.1.3** Photographs of evaluation areas. Preparation of the test facility must be coordinated with the appropriate facilities management group prior to test execution to ensure proper gravel distribution. Specifics of the number of facility cycles to be conducted and vehicle type must be provided to this group so that ample resources can be made available to maintain the facility during the duration of the testing.

**4.1.4 Exterior Styling Concept Development.** The laminate contour (painted matte black) shall be attached to the mule vehicle according to the drawing specifications. The distance between the wheel and the side wall shall be adapted to the current state of development accordingly using tracking shims. Refer to Section B1 in Appendix B.

**Note:** Alternatively, the laminate contour can have wax plates glued to it ( $\approx 0.5$  mm thick). These are painted matte black so that stone impacts are easier to see on the soft and light wax background. The left side of the mule vehicle can be used as a reference. The mule vehicle is usually a production produced vehicle whose stone chip performance has already been validated. If significant areas of this side of the vehicle are also prepared with wax plates, a comparison between the new model and the mule vehicle can be made after the test. Refer to Section B2 in Appendix B.

**4.1.5 Underbody Development.** The test parts shall be attached to the mule vehicle according to the drawing specifications. Additional brackets can be attached to the underbody for test panels. For A to B comparisons, the test panels A and B shall be in the same position on vehicle (e.g., in front of rear wheel with a 25 degree angle). Areas that are evaluated directly on the vehicle (e.g., underbody structure/components) can be covered with wax plates and painted matte black.

**4.2 Conditions.**

**4.2.1 Environmental Conditions.** Unless otherwise specified the test shall be performed at temperatures between +10 °C and +40 °C to ensure free gravel. The gravel roads should be dry for 90% or greater of the test mileage.

**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.

**4.3 Instructions.**

**4.3.1 Math Based Analysis.** The following generic instructions apply for completing the evaluation:

**4.3.1.1** Load the studio surface file to be analyzed.

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**4.3.1.2** Load the UG Stone Impingement operator.

**4.3.1.3** Enter the desired specifications (tire size, trim height, etc.)

**4.3.1.4** Execute the Stone Impingement operator.

**4.3.1.5** Inspect for any areas with impingement angles that exceed 15 degrees.

**Note:** This is not intended to provide results of the severity of the stone impingement. However, it does provide information as to the areas that will be susceptible to stone impingement damage. Road based analysis will provide the severity of the stone impingement.

**4.3.2 Road Based Analysis.** Gravel exposures for each facility are detailed in Appendix A1. The test procedures are generally summarized in Appendix A2. The local testing departments may need to provide the additional information if questions arise. However, the duration (amount of gravel exposure) should not be modified to allow for correlation from facility to facility.

**Note:** Public roads may not be used for validation testing. The test speed shall be adapted to the conditions and the specifications of the driving regulations that are distributed by the test facility. The signs on the test track shall be adhered to.

**4.3.2.1** All braking shall be light to medium according to the definitions. **Light** and **medium** have been selected because hard braking does not increase stone impact damage.

**4.3.2.2** All acceleration shall be **light** to **medium** according to the definitions. This increases the reproducibility of the tests, since wide open throttle can lead to varying results.

**4.3.2.3** The vehicle shall be kept under control at all times. The vehicle shall not drift when cornering.

**4.3.2.4** After 20%, 60%, and 100% of the test exposure, the stone impinged areas of the vehicle shall be documented by means of photographs; video or counting of stone chips in the grid zones.

## 5 Data

**5.1 Calculations.** Not applicable.

**5.2 Interpretation of Results.**

**5.2.1 Math Based Analysis.** Areas with impingement angles greater than 15 degrees should be reviewed with the studio for potential mitigation solutions.

**5.2.2 Road Based Analysis.** The stone impacts shall be evaluated in the individual phases depending on the test setup as a subjective evaluation according to GMW15290 through GMW15294 and/or GMW14700. Alternatively grid lines can be marked on the vehicle, and the number of impacts can be counted for each section. Tests with laminate contours or wax plates serve to identify susceptible stone impingement areas. As applicable, these areas can be compared with other similar areas (i.e., a left versus right comparison) if multiple scenarios are tested. Refer to Section B3 in Appendix B.

Specific chassis components such as brake lines, fuel lines, fuel tank, shock absorber oxygen sensors, electric cables, and all other functionally related underbody components shall be evaluated for both cosmetic and functional performance. End-of-test (EOT) assessment of functional performance requires detailed review if severe chipping is observed. Demonstration of part function at end of test is NOT sufficient to validate performance.

**5.3 Test Documentation.** The results of the evaluation shall be documented in a test report with reference to the test procedure and test facility (location).

**Note:** The evaluation sheets provided in Appendix C (Data Sheet C1) shall be used to evaluate/document the stone impact damage. The views of the vehicle that are needed can be created from existing math data.

## 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.

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