



Ice Clunk

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. Provide a common global development and validation performance evaluation of a driveline system that can be subject to torsional impact loading. This procedure is run to evaluate the maximum axle torque after being subjected to severe loads resulting from multiple vehicle launches on "step μ " surfaces, i.e., surfaces that change from small frictional coefficient (μ), "low μ ", to large frictional coefficient, "hi μ ". Reference GMW17196 and GMW17197 for further details.

1.2 Applicability. Vehicles that have driveline components at risk from impact loading due to driving events. For example, hybrid drive units with dampers between the engine and the drive unit. Continuously Variable Transmissions (CVT) or other transmissions that have higher inertia internal components may be considered for this test.

1.3 Remarks. This test was designed for evaluation of events that could result in high axle torques resulting from ice to dry pavement impacts that would be detrimental to the drive unit components. Hybrids have higher internal inertia than step gear transmissions due to electric motors. Damper failure modes are typically being addressed for overload, but other driveline components may be exposed to high dynamic torque events. The actual customer number of these maneuvers has not yet been determined.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW17196 GMW17197 GMW17732

2.3 Additional References.

- ETAS Incorporated, Ann Arbor, Michigan, www.etas.com
- Global Propulsion Systems (GPS) Evaluation Report Template, <https://documents.gm.com/gdm3/drl/objectId/090163bd801f824c/chronicleId/090163bd801f824c> (ID)
- Problem Resolution Tracking System (PRTS), <https://gmweb.gm.com/sites/PRTSDynamics/default.aspx> (ID)

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

3 Resources

3.1 Facilities. The test is typically run at Milford Proving Ground (MPG) or other facility with "low μ " (ceramic tiles) test surfaces such as at the Vehicle Dynamics Test Area (VDTA) of MPG, or on ice at the Winter Test Facility with adjacent dry pavement at each end (asphalt preferred) of the "low μ " surface, creating a "step μ " transition the vehicle crosses front to rear (reference GMW17196). See Table 1 for "low μ " and "hi μ " surface definitions.

Note: The test track shall have at least a 3.5 m wide test lane leading into and out of the "low μ " surface.

Table 1: Road Surface Coefficients

Road Surface	Peak Friction Coefficient (μ)	Example Road Surface
High coefficient	$\mu > 0.8$	Dry Asphalt/Dry Concrete
Medium coefficient	$0.4 < \mu < 0.7$	Wet Jennite or Wet Basalt/Packed Snow
Low coefficient	$M < 0.3$	Wet Ice, Wet Ceramic Tile, or Wet Polished Concrete/Ice

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 Driveline Torque Data for Each Driven Axle. Instrumented half shafts and/or axle shafts and associated slip rings and signal conditioning devices.

Note: Do not use wheel force transducers as wheel inertia may be different than the Original Equipment Manufacturer (OEM) recommended wheel inertia. Although wheel torque transducers may be used, the strain gaged torque axles are preferred (reference Figure A3, Appendix A), as the vehicle typically will also run the GMW17732, Panic Brake on Lo μ to Hi μ Road Surfaces, where if brakes are applied, the wheel sensors will not give an accurate torque value to the drive unit.

3.2.2 Wheel Velocity Data for Each Axle. The transducers must be capable of reading velocity in excess of the vehicle test speed, a minimum of 50 km/h over test velocity is recommended. The transducer accuracy must be within 0.5 km/h over the speed range of 5 km/h to 150 km/h.

3.2.3 Drive Unit Motor Speeds. If applicable, the motor rotor speeds should be recorded from the variables on the Controller Area Network (CAN).

3.2.4 Instrumented Traction Power Inverter Module (TPIM). If applicable, the TPIM should be instrumented to provide the necessary signals for motor speeds.

3.2.5 INCA Software (ETAS Incorporated). Recommended to be used for data acquisition as control and motor variables are able to be recorded with necessary sample rates.

3.3 Test Vehicle/Test Piece. The vehicle shall be equipped with specific driveline configuration requested. It may be possible to interchange driveline, chassis controls, tires and wheels, and powertrain hardware and software to accomplish multiple test configurations on the same vehicle. Tests to be conducted at maximum Gross Vehicle Weight (GVW) as intended for the vehicle application.

Note: All available combinations of drive unit, final drive ratios, i.e., all possible propulsion systems, and tire and wheel combinations, may need to be tested separately due to differences in driveline reactions and other hardware or electronic influences. Consult the requesting engineer for the test objectives and required combinations to meet the test objectives.

Note: Tire and wheel combinations should be the OEM recommended type, i.e., brand, size, construction, etc. Although required in many regions, snow tires often do not react similarly on artificial surfaces (ceramic tiles) as compared to actual (ice) "low μ " test surfaces. Snow tires must be tested on actual "low μ " (ice) surfaces.

3.4 Test Time. Estimate may vary based on the test matrix and number of cycles. The following is a minimal time estimate based on Global Front Wheel Drive Electric (GFE).

Calendar time: 5 days
 Test time: 20 hours
 Coordination time: 5 hours

3.5 Test Required Information. Number of ice clunk events to repeat, and number of samples with description of part content.

3.6 Personnel/Skills. Technical skills and driving skills to safely and properly execute tests.

4 Procedure

4.1 Preparation. Determine and record the number of consecutive "step μ " accelerations, throttle pedal positions and chassis/driveline mode combinations to be tested based on requirements and the following:

- Analyze the design for components at risk of inertia loading. Procure parts and develop a plan for testing, whether in a new transmission or having parts rebuilt into transmission unit for the component sample testing.
- The proper axle ratio, final drive ratio and tire sizes to be used. Consider performance tire compounds if available, to maximize traction.
- Obtain the required sample size. Typically three (3) samples of critical components are procured for the tests. The third test may be run to higher number of cycles or failure for confirmation of failure mode.
- Number of consecutive Ice Clunk tests to be run in each mode or alternated between various points. Typically, a total of fifty 100% pedal and fifty lift foot events are run.
- If vehicle is All Wheel Drive (AWD), consider the worst condition either Front Wheel Drive (FWD) or Rear Wheel Drive (RWD) and if any special conditions to be set for the testing objective. Modification to the procedure to be documented in the report.
- If run as a development test, mitigation for controls must be defined and documented. Investigate the ability of the control system software level to be capable of running the test.
- For validation, consider a 65% or higher calibration level of maturity.
- Determine the matrix of transmission drive unit modes or ranges to run as determined from Design Failure Modes and Effects Analysis (DFMEA) or other risk analysis.

Note: See Table C2, Appendix C for Global Rear Wheel Drive Electric (GRE) modes to run.

4.2 Conditions.

4.2.1 Environmental Conditions. Dry road conditions for "hi μ " surface; wet on the ice simulation "low μ " surface or ice. Road surface coefficients are defined in Table 1.

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. See Appendix A, Figure A1 for FWD, and Figure A2 for RWD, for a diagram of the ice clunk test pad. For GRE applications refer to Appendix C, Table C1 and Table C2.

4.3.1 One Hundred Percent, i.e., 100% Pedal Ice Clunk.

4.3.1.1 Enter the ceramic pad at 16 km/h (10 mph).

4.3.1.2 Just before the drive wheels transition to the "hi μ " surface, apply 100% travel of accelerator pedal.

4.3.1.3 Hold pedal until transition to "hi μ " surface of the drive unit tires is obtained.

4.3.1.4 Cycle ends when peak torque is obtained on "hi μ " surface.

4.3.1.5 Repeat for desired number of events.

4.3.2 Lift Foot Ice Clunk.

4.3.2.1 Enter the ceramic pad at 16 km/h (10 mph).

4.3.2.2 Just before the drive wheels transition to the "hi μ " surface, apply 100% travel of accelerator pedal.

4.3.2.3 Release the accelerator pedal immediately before the drive unit tires contact the "hi μ " surface.

4.3.2.4 Cycle ends when peak torque is obtained on "hi μ " surface.

4.3.2.5 Repeat for desired number of events.

5 Data

5.1 Calculations. Not applicable.