



Gaseous Fuel Engine Cold Start and Driveability – Subjective Evaluation

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 subjectively evaluate engine cold starting capability and driveability characteristics of a gaseous fueled vehicle after being stabilized for a minimum time period at any given ambient temperature.

1.2 Applicability. Passenger cars and light duty trucks equipped with mono-fuel or bi-fuel systems. The gaseous fuel can be Compressed Natural Gas (CNG) or Liquefied Petroleum Gas (LPG).

1.3 Remarks. This procedure documents the process for developing and validating the cold starting capability and driveability characteristics of a gaseous fueled vehicle.

This schedule may be used to evaluate the engine driveability characteristics of prototype vehicles or for auditing production vehicles. It consists of a specific series of maneuvers that are designed to simulate customer usage.

Any vehicle rating generated by less than the full test sequence should be identified when presenting test results. The vehicle rating may be affected by ambient temperature, fuel, and the road system used. Fuel used should be appropriate for ambient conditions, as specified by the Requesting Engineer, or as specified in the Vehicle Owner's Manual.

This procedure includes an optional extended initial idle to simulate a delayed drive-away resulting from a remote start, vehicle loading or window clearing.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14264

2.3 Additional References.

- Emission Control Information Label
- Powertrain Gaseous Fuel Engine Management System (EMS) Fuel Delivery Subsystem Technical Specification (SSTS)
- Vehicle Owner's Manuals
- Vehicle Technical Specification (VTS)

3 Resources

3.1 Facilities. A vehicle test facility having a level, reasonable smooth track, designed for cold start and driveability evaluations. The soak area must allow a 90 degree turn in reverse driving maneuver. The test facility and track must be operational when the ambient temperature is from -29 °C to 0 °C (-20 °F to 32 °F).

The General Motors Cold Weather Development Center in Kapuskasing, Ontario, Canada, or the equivalent, is recommended.

This procedure may be used in a climate controlled room with a chassis dynamometer, but the results may not correlate directly with road test results.

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.

- a. Stopwatch.
- b. Thermometer or Thermocouple readout.
- c. Clipboard for datasheet or,
- d. Laptop/notebook computer.

Note: All instrumentation must be calibrated. Record instrumentation details and the date of calibration in the test records unless the information is otherwise preserved in the testing facility records.

3.3 Test Vehicle/Test Piece. The test vehicle to be evaluated using the recommended start procedure intended for the Vehicle Owner's Manual.

3.4 Test Time.

Calendar time:	1 day
Test minutes:	20 minutes
Coordination hours:	2 hours

3.5 Test Required Information.

- Fuel quantity (LPG level or CNG pressure).
- Fuel composition.
- Software/Calibration/EMS hardware level.
- Altitude above sea level.

3.6 Personnel/Skills. Engineering test personnel with powertrain experience in engine calibration, dynamic vehicle testing and, drive quality testing is recommended.

Prior experience in conducting similar tests is critical to achieving repeatable, objective and accurate results.

The Lead Calibrator for the Gaseous Fuel EMS is responsible to provide a calibration that is suitable for testing and representative of production intent. During test, the lead calibrator or alternative should be available for consultation.

The Validation or Quality Engineer is responsible to assure that the test is successfully completed by either participating in, or monitoring the testing and resulting data from others.

4 Procedure

4.1 Preparation.

4.1.1 Vehicle Instrumentation. The minimum instrumentation required is a thermocouple to record the temperature of the ambient air. At the request of the Test Engineer, additional thermocouples may be added.

Install a thermocouple readout or data acquisition equipment (if used). Confirm the connections are correct and that the equipment operates at low ambient temperatures.

4.1.2 Vehicle Preparation.

4.1.2.1 Confirm all engine, fuel, cooling, Exhaust Gas Recirculation (EGR), Positive Crankcase Ventilation (PCV), air induction and exhaust system components are production intent and installed correctly.

For production audit purposes, the test vehicle should conform to specifications in the Vehicle Owner's Manual and Emission Control Information Label.

4.1.2.2 Confirm that the engine and gaseous fuel controls calibration and software are production intent.

For engineering development or validation purposes, the status of the Gaseous Fuel EMS components, software and calibration must be recorded.

4.1.2.3 Confirm that the engine coolant provides adequate protection for -40 °C (-40 °F).

4.1.2.4 The gaseous fuel container must be at least one-half full. The gaseous fuel must be the correct composition for the ambient temperature test conditions.

For bi-fuel vehicles, the gasoline/petrol fuel tank must be at least one-half full with the correct seasonal blend for the ambient temperature test conditions.

4.1.2.5 Record the vehicle details, fuel and initial test conditions on Data Sheet B1 or Data Sheet B2 found in Appendix B or electronic equivalent.

4.1.3 Test Preparation. Before parking the test vehicle for the soak period, it must be driven for normalization as per Table 1.

Table 1: Normalization Distance

Ambient Temperature	Distance
≥ -18 °C (10 °F)	16 km (10 mi)
< -18 °C (10 °F)	32 km (20 mi)

The normalization drive shall include five idle periods of 10 s to 30 s duration. Vehicle speed shall not exceed 80 km/h (50 mph).

Return to cold soak area and park the vehicle with steering centered, such that it can be reversed in a 90 degree turn maneuver to begin the test. Idle for 10 s with all accessories off.

Place heater/air conditioner control in the defrost mode (i.e., the highest possible electrical and mechanical engine load condition) with blower fan switch in high position and the temperature set to a minimum tolerable level.

Shut the engine off and record the park time.

Note: The electrical loads may be modified as directed by the Test Engineer.

Soak the test vehicle for a minimum of 12 h and a maximum of 24 h.

For saleable, pilot or production vehicles:

- a. Any base engine or EMS repairs required because of a malfunction during the test preparation shall be penalized 12 demerits.
- b. If a warning light (e.g., Malfunction Indicator Lamp (MIL), oil, etc.) appears during the vehicle preparation and/or test, complete the test, if possible, and penalize the vehicle 12 demerits.

4.2 Conditions.

4.2.1 Environmental Conditions. This test procedure can be conducted in all types of weather, but not when wind speed exceeds 25 km/h (15 mph) or with gusts above 40 km/h (25 mph).

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 Cold Start. The word cold as used in this procedure is a relative term. The first time the vehicle is started each day is considered the cold start even at high ambient temperatures. It is important to run cold starts on bi-fuel vehicles that start on gasoline/petrol. At some time during the test, the vehicle typically switches from operating on gasoline/petrol to gaseous fuel and the fuel transition can be evaluated.

4.3.1.1 At ambient soak temperatures below -18 °C (0 °F), it is strongly recommended to install conditioned batteries at 80% State of Charge (SOC) after the soak period and before the start of test.

4.3.1.2 Record the ambient temperature, soak time and fuel used for starting the engine. Use the throttle position for cold starts as specified by the Test Engineer or as described in the Vehicle Owner's Manual.

4.3.1.3 As required by the vehicle configuration, initiate the engine start sequence by inserting the ignition key or retaining/docking the keyless device. As required, turn the key to the "Start" position or depress the "Start" button. Release key or button as soon as the engine starts.

If engine does not start, release the key or button after the maximum cranking time specified by the test engineer or the Vehicle Owner's Manual.

Record cranking time in seconds on Data Sheet B1 or Data Sheet B2 found in Appendix B. Assign demerits as shown in Table 2.

Table 2: Cold Engine Start Demerits

Ambient Temperature Range	Start Grace Period	Crank Time Demerits	Stall Demerits	Restart Grace Period
$T \geq 0^{\circ}\text{C}$ ($T \geq 32^{\circ}\text{F}$)	2 s	1 for each 0.5 s	6 each	1 s
$-18^{\circ}\text{C} \geq T < 0^{\circ}\text{C}$ ($0^{\circ}\text{F} \geq T < 32^{\circ}\text{F}$)	3 s	1 for each 0.5 s	6 each	2 s
$-23^{\circ}\text{C} \geq T < -18^{\circ}\text{C}$ ($-10^{\circ}\text{F} \geq T < 0^{\circ}\text{F}$)	4 s	1 for each 0.5 s	6 each	2 s
$-29^{\circ}\text{C} \geq T < -23^{\circ}\text{C}$ ($-20^{\circ}\text{F} \geq T < -10^{\circ}\text{F}$)	5 s	1 for each 0.5 s	6 each	2 s

Example: Ambient temperature is -5 °C (23 °C). The engine starts in 5 s, stalls once, and restarts in 5 s.

$$\begin{aligned}\text{Start Demerits} &= (5 - 3) \times (1/0.5) + 6 + (5 - 2) \times (1/0.5) \\ &= 2 \times 2 + 6 + 3 \times 2 \\ &= 4 + 6 + 6 \\ &= 16\end{aligned}$$

For ambient temperatures below -29 °C (-20 °F), unassisted starting is not a requirement. If engine block, coolant or battery heaters are used, demerits are the same as for -29 °C (-20 °F).

4.3.1.4 If the engine does not start, repeat the start procedure in 4.3.1.3, after the waiting period specified by the test engineer or in the Vehicle Owner's Manual. Continue this starting sequence until the engine starts or 100 demerits have been accumulated.

Note: Throttle adjustments using the accelerator pedal to assist engine firing are not permitted unless advised in the Vehicle Owner's Manual.

4.3.2 Cold Idle.

4.3.2.1 As soon as the engine starts, turn on all available electrical accessories except for the radio/sound system which should be turned off. Keep the heater/air conditioner controls in the defrost position at minimum tolerable temperature. The fan speed should be adjusted to the lowest setting that allows safe vehicle operation

The radio/sound system and fan settings are required to provide a quiet ambient for assessing engine roughness, detonation and dieseling.

Note: The electrical loads may be changed at the direction of the test engineer.

For manual transmissions, evaluate the quality of engine idle for 10 s with the clutch pedal depressed (disengaged) and for 10 s in neutral with the clutch pedal released (engaged).

For automatic transmissions, evaluate the quality of engine idle for 10 s with the selector in the **Park** position and for 10 s in the **Reverse** position with the brakes applied.