



Global Engine Durability (GED) Test – Vendor Version

1 Scope

Note: Security. This document may be released to vendors that supply engine components to or test engines for General Motors. There is a GM Confidential version of this document which may not be released outside of General Motors.

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 test is primarily run to determine the durability characteristics of the basic structure of the engine. Being an accelerated test, it does not duplicate customer usage, but intends to generate similar cumulative stresses and wear as would occur in the useful life of the vehicle.

1.2 Foreword. The operating parameters of this test have been related to the application of the engine being tested. General Motors will provide the specific information for each given engine. In general the test set-up should allow the engine to experience similar conditions as in the vehicle. Modifications to the engine for the purpose of testing should be kept to a minimum.

1.3 Applicability. The procedure is written in generic terms to cover all internal combustion engines.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GME L-6A2-6 GMW16398

GMW16166 GMW16401

2.3 Additional References.

- Test Code Book (7th edition, "Vehicle Exhaust Backpressure Measurement Techniques")
- TP 1149 – Nitrogen Leak Check. See also GME L-6A2-6.
- TP 1272 – Engine Check-out (Durability Break-in)
- TP 3707 – Cranking Compression Test
- TP 3708 – Cylinder Leakage Test

3 Resources

3.1 Facilities. Major Facility - Engineering Test Laboratory; Minor Facility - Dynamometer Test Cell.

3.2 Equipment.

3.2.1 Dynamometer. Suitably rated for the speed range and torque output of the engine to be tested. Motoring capability not required.

Note: Some motoring dynamometers may be damaged by sustained high speed/high load tests such as Global Engine Durability (GED).

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3.2.2 Propshaft. Suitably matched to inertia and torque output of the engine, inertia of the dynamometer being used, and the maximum speed of the test.

Note: Improper shaft selection could lead to reduced shaft life and false failure modes caused by incorrect vibration conditions, e.g., elevated high-speed crankshaft torsionals or low speed propshaft “rattles”.

3.2.3 Transmission. Connect one to the engine only if requested by the Test Engineer. (Document whether or not a transmission is used.) If used, it should be locked in a specific gear to prevent shifting and allow the dynamometer to control engine speed according to the dynamometer controller. The torque converter should also be locked in order to have engine speed equal dynamometer speed. Inertia weights are not required.

3.2.4 Throttle actuator. With linkage, used for automatic throttle control.

Note: This system may need to accommodate electronic throttle control systems.

3.2.5 Dynamometer Controller. To manage engine speed, engine load and pedal per Table A1: GED Steps and Figure A1: Global Engine Durability Cycle.

3.2.6 Coolant Cooling System. It must incorporate the following features:

- A closed system with vehicle equivalent flow restrictions.
- A sight glass to visually monitor coolant condition.
- An active thermostat. See 3.3.8.
- Production equivalent by-pass loops (e.g., heater, oil cooler, internal, etc.)
- Other vehicle equivalent features (e.g., overflow/pressure bottle, etc.)
- Cooling system components should have proper relative orientations to allow appropriate air purging, etc.
- The maximum system pressure is to not exceed the vehicle radiator cap relief pressure.

Note: External pressurization of the coolant system is not appropriate unless the design of the system prevents the attainment of minimum vehicle pressure levels at equivalent engine speed/coolant temperature conditions.

3.2.7 Oil Cooling System. With vehicle equivalent flow restrictions. Internal engine oil flow is not to be disrupted. The quantity of oil in the oil cooler should be kept to a minimum so that the oil quality degradation rate will not be affected. All test sites must duplicate the oil cooling method used at the design test site for a given family of engines. At start of test (SOT) or fluid change, the whole system should have new oil.

Note: Oil cooling may not be necessary if the oil sump temperatures found in 4.2.2 (k) are not exceeded while on schedule.

Warning: Oil cooling system must be replaced or carefully flushed/back-flushed following an engine failure.

3.2.8 Temperature Controllers. To maintain oil and coolant temperatures per 4.2.2 (k) and 4.2.2 (j).

3.2.9 Exhaust System. Capable of providing vehicle equivalent backpressure. See 3.3.3, 3.3.4 and 4.1.1 (c).

3.2.10 Fuel Delivery System. Capable of maintaining production (intent) vehicle pressure and flow.

Warning: Excess fuel temperature can cause flow problems (vapor lock).

3.2.11 Instrumentation. As needed to measure the parameters found in section 5.1.

3.2.12 Shut Down Devices. For engine safety to respond to conditions in section 6.2.

3.2.13 Flight Recorder. Must be capable of holding at least 30 s of data before a shutdown and 5 s of data after.

Should be capable of holding one hour of data. Specifically:

1. 10 samples/second for last 3 minutes.
2. 1 sample/second for last 10 minutes.
3. 1 sample/minute for last 60 minutes.
4. Track for 2 minutes after limit condition at 1 sample/second.
5. Computer should hold 2 sets of this and should ask operator if he or she wants to restart after limit shutdown without saving data.

3.2.14 Automatic Data Acquisition Equipment. Must be capable of a 10 Hz minimum raw signal sample rate and able to average raw signal values into data for recording. See section 5.1.

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3.2.15 Intake Air Condition. Provisions for maintaining the intake air temperature at 16 to 38 °C (60 to 100 °F) and pressure of 95 to 105 kPa (28 to 31 inches Hg). See section 4.2.1.

3.3 Test Vehicle/Test Piece.

3.3.1 Engine. All pre-durability measurements prescribed by the Design/Release Engineer(s) must be made and recorded in the Engine Build Room (unless plant built). Clearances are to be within production (intent) specifications. Use multi-spindle tools for assembly as early in the development process as possible.

3.3.2 Complete Accessory Drive System. A complete accessory drive system should be used.

3.3.3 Active Emissions Equipment. Production (intent) system, including: Positive Crankcase Ventilation (PCV) system (without oil catch jars), Air Injection Reaction (AIR) system (engine mounted hardware), functioning Exhaust Gas Recirculation (EGR) system, pre-catalyst oxygen sensors, etc. The use of under-floor catalytic converter(s) is optional, though exhaust manifold-integral/close-coupled converters are recommended. (Document whether or not converters are used.) If catalytic converters are used, the catalyst should be inert. Any other emissions systems which mount on the engine or affect its operation should be included.

Note: Some products have had over-temperature problems in dynamometer test cells with heated O₂ sensors; if using non-heated sensors as a replacement, there must be supporting vehicle temperature data. See 4.1.1 (p).

3.3.4 Exhaust. Use production (intent) exhaust manifold(s). Run rest of exhaust parts if possible within limitations of test cell.

3.3.5 Ignition System. Use the production (intent) system.

Active Electronic Spark Control (ESC) should be used, but only if it works properly in the test cell environment. (Document whether or not ESC is used.)

Production (intent) spark plugs are recommended, but “colder” plugs may be used if the ESC system does not function properly or if inlet air > 38 °C (100 °F) due to facility limitations. (Document which spark plugs are used.) The spark plugs are to be set at production (intent) gap.

3.3.6 Production Engine Control Module (ECM)/Powertrain Control Module (PCM)/Vehicle Control Module (VCM). Software and calibration for electronically-managed engine controls. The spark, fuel, and emissions calibrations are to be the same as vehicle or at least latest level during a development program with active timers, etc. Document all changes made to the calibration – changes are to be kept to a minimum. Non-engine codes (e.g., transmission, Vehicle Anti-Theft System (VATS), etc.) may need to be masked and routines that affect engine performance for non-engine related reasons (e.g., torque management, traction control, etc.) should be disabled.

3.3.7 Engine Fluids. Factory fill (production intent for model year of system being tested) engine oil.

Use factory source coolant at the as released mix (typically 50/50) for the model year of the system being tested. The use of coolant supplement pellets is not recommended since they may hide design/quality flaws.

Primary vehicle specified fuel type (e.g., ethanol, Liquefied Petroleum Gas (LPG), Compressed Natural Gas (CNG), gasoline, diesel) is recommended. If engine performs better on premium, use premium for 1 or 2 engines (in cases where premium fuel use is not required by Owner's Manual). Additionally, the lowest octane fuel allowed by the Owner's Manual may be used for 1 to 2 engines. (**Note:** Retarded spark testing is also covered during Global Engine Thermal Cycle (GETC) test).

Note: For gasoline engines fuel with a higher octane number may be used if the ESC system is not working properly, not yet calibrated, or if the inlet air temperature is > 38 °C (100 °F) due to facility limitations. (Document which fuel is used.)

3.3.8 Thermostat. Use an active production (intent) thermostat. If it has been demonstrated that engine failures have resulted from using an active thermostat and that these failures do not exist in the vehicle; then a pinned open thermostat may be used. Pin open thermostat to a level equal to nominal coolant temperature (nominal production thermostat “start to open” temperature plus 6 °C) for test.

Note: If a fully (per drawing) pinned open thermostat must be used, then the coolant temperature must be raised to match this condition. See 4.2.2 (j).

3.3.9 Induction Hardware. Production (intent) complete induction system.

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3.4 Test Time. To be provided by General Motors.

Calendar time: Varies days

Test hours: Varies hours

Coordination hours: Varies hours

3.5 Test Required Information. To be provided by General Motors.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Sample Preparation.

- a. Mount the engine with associated test material from 3.3.2, 3.3.3, and 3.3.8 on the dynamometer test stand. Engine mounting that yields vibration levels representative of the actual vehicle environment is recommended since hard mounting causes high vibration levels, which may lead to false failures of brackets, baffles, etc.

Document the type of mounting system used. It is also desirable to mount the engine so the crankshaft is parallel (within $\pm 0.5^\circ$) but not in-line with the axis of the dynamometer shaft to eliminate unrepresentative second order torsional vibrations induced by propshaft universal joints.

Note: Put the propshaft at the proper angle per the specifications of the supplier.

- b. Connect transmission to the engine only if requested by the Test Engineer. See 3.2.3 (Document whether or not a transmission is used.)
- c. Connect the exhaust system to the engine. The backpressure should be set to the vehicle equivalent level (Select the lowest backpressure application.) per the appropriate Test 1 procedure (transient or steady state) in the Test Code Book (7th edition, "Vehicle Exhaust Backpressure Measurement Techniques").

Note: Avoid making the dynamometer exhaust system too heavy or too rigid for the engine exhaust parts as this may lead to false failures.

Note: If measurement technique differs from vehicle to dynamometer (e.g., kiel to static) any offsets must be accounted for.

- d. Connect the air filter housing to the engine. It should contain a new air filter element. The induction system should be at the same orientation as the vehicle.
- e. Connect the fuel lines to the engine. The fuel delivery system should be adjusted to maintain the production (intent) vehicle pressure.
- f. Connect the ignition (per 3.3.5) and the engine control (per 3.3.6) systems to the engine.
- g. Connect the throttle linkage to the engine. Adjust it if necessary to obtain closed throttle and wide open throttle (WOT) conditions.
- h. Connect the coolant (per 3.2.6) and the oil (per 3.2.7) cooling systems to the engine.
- i. Fill the coolant cooling system with fresh factory-fill coolant per 3.3.6.

Note: Make sure the system is full of coolant without trapped air pockets; the active thermostat will make the fill more difficult.

- j. Install a new production (intent) oil filter.
- k. If necessary, calibrate the dipstick per the Test Engineer's instructions (**Note:** GMW16401 Oil Level Indicator (Dipstick) Calibration Procedure is available).

WARNING: May need to re-calibrate dipstick for applications which are at an angle in the vehicle but at 0° in dynamometer cell.

- l. Fill the engine with factory fill oil to the "FULL" mark (top of operating range). Recheck the oil level after running the engine for a couple of minutes. (Adjust if necessary to achieve "FULL" mark.)
- m. If the engine has a base timing which is adjustable, then:

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1. Verify the timing mark is at 0 when piston No. 1 is at top dead center (TDC) (If not, document; then correct.) and
 2. Set the base timing to the nominal production (intent) specification.
- n. If adjustable, then tension the accessory belt(s) per the production (intent) specification. If not adjustable, then the production (intent) tensioner(s) should be used.
 - o. If accessory loading is requested by the Test Engineer; then make the necessary connections to accomplish this. (Document whether or not accessories are loaded.)
 - p. Auxiliary cooling (e.g., with blowers, fans, etc.) should only be used if it can be demonstrated that component temperatures in the dynamometer environment exceed the maximum temperatures found in the vehicle. Document any parts being cooled or insulated.

4.1.2 Facilities Preparation.

- a. Program dynamometer controller to run the GED schedule per Figure A1 and Table A1. See also section 4.2.2.

With an absorbing dynamometer it is not possible to execute a closed throttle deceleration with a specified ramp time – as soon as the throttle is closed there is not enough load to control the deceleration. As a result, the engine speed drops too quickly and the engine drops to a speed below the desired endpoint.

For this reason steps 14, 21, and 28 (see Figure A1 and Table A1) have been split into two sections each – a and b. The “a” step will be closed pedal and ends when the speed is within 25% of Speed B. The “b” step will open the pedal to provide just enough load to seek Speed B. Since the deceleration to Speed B will very likely take less time than specified for a + b, any remaining time will be spent at Speed B.

This approach quickly removes load, provides maximum inertia loads at high speed, provides the correct step time, and ends at the proper speed without overshoot. It does not provide a linear speed response.

- b. Set the oil and coolant temperature controllers (If used - see 3.2.7.) to maintain temperatures per 4.2.2 (k) and 4.2.2 (j).

Note: The control point for the coolant temperature controller should match the thermostat location, i.e., coolant-out for an outlet thermostat and coolant-in for an inlet thermostat.

Note: If using a cooler for the oil (see 3.2.7) then the control point for the oil temperature controller should be the oil-in/gallery location. This position provides more stable oil temperatures and pressures than does the oil sump position. This position also provides an oil sump temperature response to engine speed that is more representative of in-vehicle conditions.

- c. Connect the instrumentation to measure the parameters found in Section 5.
- d. Set the engine safety shut down limits per section 6.2.
- e. Set the sample rates for the flight recorder and data acquisition equipment.

4.1.3 Instrument Calibration. Perform all pre-test calibrations on load cells and other required instrumentation.

4.2 Conditions.

4.2.1 Environmental Conditions.

- a. Intake Air Temperature: 16 to 38 °C (60 to 100 °F)
- b. Intake Air Pressure: 95 to 105 kPa (28 to 31 inches Hg)

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.

The following speed point descriptions relate to the waveform shown in Figure A1 and described in Table A1.

- a. **Idle Speed (Speed A):** Use vehicle idle. This speed may be raised if dynamometer friction causes the engine to stall or if propshaft rattle (see 3.2.2) occurs.
- b. **Minimum Cycling Speed (Speed B):** Use (based on drivability at WOT for 4 cycle engines):
 - 1800 rpm for 3 cylinder engines
 - 1600 rpm for 4 cylinder engines
 - 1500 rpm for 5 cylinder engines

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