



Exhaust Gas Recirculation (EGR) System Durability Test Procedure

1 Scope

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 used to evaluate the durability of the engine management system (EMS) hardware, with an emphasis on the exhaust gas recirculation (EGR) system hardware. This test is a repeating loop that is primarily composed of the Standard Road Cycle (SRC). While running this repeated driving cycle the engine is transitioning in and out of various operating modes. The time spent in each operating mode is proportioned appropriately, assuming the inputs required by the EGR System Durability Test Calculator. Rated power, maximum heat load EGR (defined in 4.2.2), and hot soak portions are also included to assess the hardware durability to the failure modes most susceptible to those operating conditions.

1.2 Foreword. The vast majority of the test loop is spent running the SRC driving cycle (see Section A1.2). The SRC was developed by the Environmental Protection Agency (EPA) in 2005, and it is used for predicting emissions hardware deterioration over the full useful life of light-duty vehicles. The EGR System Durability Test was designed for light-duty diesel applications, but is suitable for other applications. This standard is appropriate for an engine if its vehicle application usage is well represented by the SRC.

Operating at low speed/light load conditions typically requires EGR (this may vary depending upon the application and the engine operating mode; e.g., Diesel Particulate Filter (DPF) regeneration, Selective Catalyst Regeneration (SCR) warmup, etc.) in varying amounts. This EGR requirement necessitates the movement of the EGR valve to continually throttle the EGR gas to the needs of the engine. Also, if applicable, the EGR cooler bypass valve may be cycling to protect the cooler from heavy fouling conditions, and to control the temperature of the EGR gas. These two valves will depreciate with such use, and this is a major advantage of this testing. The high EGR use that is expected from this test will also cause exhaust contaminant accumulation on EMS components. This accumulation will restrict flow, induce valve sticking, and reduce the effectiveness of the EGR cooler. Also, the use of various operating modes exposes the hardware to conditions only seen in those modes (e.g., post-injection, elevated bypass EGR temps, etc.) Rated power, maximum heat load EGR, and hot soak portions are also included to assess the hardware durability against the failure modes most prone to those operating conditions.

The long test duration may drive certain Programs to run only a percentage of this test in the interest of Program timing, lab resources, etc. The Pre-/Post-Test Criteria sheet should be used to track the wear and performance degradation of all relevant hardware. The known correlation, between the actual number of test hours (as chosen by the Program) and the required Total Test Hours (U), should provide a meaningful indication of whether or not the hardware is durable to the system requirements.

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

1.4 Security. Except as noted here, none of the text, procedures, tables, or numbers in this document may be released outside General Motors. If a company outside General Motors is to conduct testing based on this procedure, the following information **may** be released:

- The required content of the test (how many hours/cycles, the speeds, the temperatures, etc.) or a separate document which gives this information.
- The test reliability (and associated confidence) to be demonstrated on the test.
- Recommendations for continued testing for failure and for analysis of the results.
- Requirements for reporting the test results to GM.

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Information about how the test reliability was determined **may not** be released. For example, background on how the test inputs were selected (such as the customer severity being represented) or the field reliability that corresponds to the required test reliability, **may not** be released. Information about how the life goal, speeds, or temperatures were determined **may not** be released.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Subsystem Technical Specifications (SSTS)
- Vehicle Technical Specifications (VTS)

Note: This data may change during an engine program or from model year to model year. Make sure the data is kept current.

2.3.1 Vehicle Installation Angle.

3 Resources

3.1 Facilities. Major Facility: Engineering Test Laboratory.

3.2 Equipment.

3.2.1 Dynamometer. Suitably rated for the speed range and torque output of the test conditions. Motoring capability is not required.

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.

3.2.3 Throttle Actuator. With linkage, used for automatic throttle control.

3.2.4 Dynamometer Controller. To manage engine speed, engine load/accelerator pedal position (APP) per the test cycle.

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

- A closed system with vehicle equivalent flow restriction.
- A sight glass to visually monitor coolant condition.
- 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 be equal to 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.

3.2.6 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, depending on the application.

3.2.7 Temperature Controllers. To maintain oil, coolant, and fuel temperatures per 4.2.2.1 thru 4.2.2.2.

3.2.8 Exhaust System. Capable of providing vehicle equivalent backpressure (see 3.3.7). A vehicle exhaust after treatment system is not required by the test procedure.

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Documents

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Note: Check with your test lab to make sure that the engine-out emissions are acceptable for your lab exhaust system (e.g., post-injection may cause raw fuel to be mixed in with the engine out emissions). Nothing in this standard supersedes applicable test lab rules and regulations.

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

3.2.10 Instrumentation. As needed to measure the parameters found in Section 5.1.

3.2.11 Automatic Data Acquisition Equipment. Must be capable of a 1 Hertz or greater minimum raw signal sample rate and be able to average raw signal values into data for recording. See Section 5.1.

3.2.12 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 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). The engine should be broken-in prior to beginning any cycle tuning.

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

3.3.3 Production Engine Control Module (ECM). Hardware and software/calibration for electronically-managed engine controls may be required. The engine calibrations are to be the same as used in the vehicle or at least the latest available level during a development program. Calibration changes should only be made if absolutely necessary. Changes should be documented. Non-engine codes (e.g., transmission, 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. The test procedure requires automated control of the engine operating mode. The Test Engineer should assist in achieving this capability.

3.3.4 Engine Fluids. Factory fill production (intent), for model year of system being tested, engine oil should be used. 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 should be used. If the test is to be run more than once, alternative fuels can be used (e.g., ethanol, biodiesel, etc.)

3.3.5 Induction Hardware. Production (intent) with complete induction system.

3.3.6 Thermostat. Use a pinned open thermostat.

3.3.7 Exhaust. Use production (intent) exhaust manifold(s). Test engineer should use discretion when deciding what downstream (e.g., muffler, converter, SCR, DPF, etc.) exhaust hardware to include. Downstream hardware is not required by the test procedure (see 3.2.8).

3.3.8 Ignition System (Gas Engine). Use the production (intent) system. Active Electronic Spark Control (ESC) should be used. Production (intent) spark plugs are required. The spark plugs should be set at production (intent) gap.

3.4 Test Time.

Calendar time: Varies days

Test hours: Varies hours

Coordination hours: Varies hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Test Cycle Definition. The GM Test Engineer should collect the EGR System Durability Test Calculator inputs (see Section A1.3 in Appendix A), and define the test cycle per 4.2.2. (See also Sections A1.1 and A1.2 in Appendix A.)

4.1.2 Pre-/Post-Test Criteria Sheet. This template form (see Section A1.4) should be used to create an application specific criteria sheet.

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4.1.3 Sample Preparation.

4.1.3.1 Mount the engine with associated test material from Section 3.3 in the dyno test cell. Use production (intent) mounts if possible. Mount engine at the same installation angle as in the vehicle.

4.1.3.2 Connect the exhaust system to the engine. If downstream exhaust hardware is not used, set exhaust back pressure to approximate vehicle back pressure (see 3.3.7).

4.1.3.3 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.

4.1.3.4 Connect the fuel lines to the engine.

4.1.3.5 Connect the ignition (if applicable, per 3.3.8) and the engine control (per 3.3.3) systems to the engine.

4.1.3.6 Connect the throttle linkage to the engine.

4.1.3.7 Connect the coolant (per 3.2.5) and oil (per 3.2.6) conditioning systems.

4.1.3.8 Fill the coolant cooling system with fresh factory-fill coolant (per 3.3.4).

Note: Make sure the system is full of coolant without trapped air pockets.

4.1.3.9 Install a new production (intent) oil filter.

4.1.3.10 If necessary, calibrate the dipstick per the Test Engineer's instructions.

4.1.3.11 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 the "FULL" mark.

4.1.3.12 If the engine has a base timing which is adjustable, then:

- (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.

4.1.3.13 If adjustable, tension the accessory belt(s) per the production (intent) specification. If not adjustable, then the production (intent) tensioner(s) should be used.

4.1.3.14 Connect the instrumentation to measure the parameters found in 5.1.1.

4.1.3.15 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.

4.1.4 Instrument Calibration. Calibrate all instrumentation as required prior to start of test.

4.2 Conditions.

4.2.1 Environmental Conditions. No special requirements, although ambient temperature range should not exceed 10 to 40 °C.

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.

See Figure A1 in Appendix A for an example plot of the Test Cycle. The descriptions below should be used by the GM Test Engineer to properly operate the EGR System Durability Test Calculator and define the test cycle. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

- **Test Goal:** The vehicle mileage/lifetime requirement for which the engine must be validated.
- **Idle Speed:** Engine speed at idle (in "Park").
- **Rated Power Speed:** Engine speed at which power (observed) is maximized.
- **Maximum Heat Load Speed:** Engine speed at which the EGR exhaust temp is maximized, while still maintaining a high EGR flow rate.

Note: Engineering discretion should be used.

- **Maximum Heat Load APP:** Accelerator pedal position at which the EGR exhaust temp is maximized, while still maintaining a high EGR flow rate.

Note: Engineering discretion should be used.

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