Shuttle Exhaust Gas Recirculation (EGR) Cooler Fouling 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. To evaluate the cooler fouling effects of extended idle, with cooled EGR operation. This test is comprised of a repeating cycle which includes long periods of idle alternating with light load driving.

1.2 Foreword. This test was designed for heavy duty diesel applications such as shuttle, delivery, ambulance, extended Power Take Off (PTO) use, etc. This test may/may not be appropriate for other applications. Operating at low speed/light load conditions typically requires EGR (this may vary depending upon the engine operating mode, e.g., Diesel Particulate Filter (DPF) regeneration, Selective Catalyst Reduction (SCR) warmup, etc.) If the engine lacks an EGR cooler bypass valve, the EGR passes through the EGR cooler. This results in exhaust contaminant accumulation on the internal EGR cooler fins. This accumulation restricts flow, and reduces the effectiveness of the cooler. The test includes extended idle portions alternating with a part-throttle driving cycle.

1.3 Applicability. The procedure is written in generic terms to cover all internal combustion engines that include EGR coolers. Use engineering discretion to determine if this test is appropriate for a specific application.

1.4 Security. Except as noted in the following list, 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.

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)

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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/pedal position per Appendix A.

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.

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 Hz minimum raw signal sample rate and be able to average raw signal values into data for recording (see Sections 5.1 and Table A1 in Appendix A).

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 broke-in prior to beginning the cycle tuning. The EGR cooler should be replaced after the test script is proven to be correct during cycle tuning.

3.3.2 Short-Belt Accessory Drive System. Full accessory drive system is not required. However, the Fouling Cycle engine loads need to be carefully controlled to ensure the severity of the test. If Points A and B were chosen using data from an engine with a full accessory drive, this hardware may be required on the test engine.

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

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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, 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.

3.3.4 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., biodiesel, ethanol, 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, Diesel Oxidation Catalyst (DOC), SCR, DPF, etc.,) exhaust hardware to include. Downstream hardware is not required.

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 Sample Preparation.

4.1.1.1 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.

4.1.1.2 Connect the exhaust system to the engine. If downstream exhaust hardware is not used, set exhaust back pressure to approximate vehicle back pressure.

4.1.1.3 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.

4.1.1.4 Connect the fuel lines to the engine.

4.1.1.5 Connect the ignition (per 3.3.8) and the engine control (per 3.3.3) systems to the engine.

4.1.1.6 Connect the throttle linkage to the engine.

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

4.1.1.8 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.

4.1.1.9 Install a new production (intent) oil filter.

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

4.1.1.11 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.

4.1.1.12 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.

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

4.1.1.14 Connect the instrumentation to measure the parameters found in Section 5.1.1.

4.1.1.15 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.

4.1.2 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.

The Test Engineer should prepare the test script per Appendix A.

The driving cycle should be driven in the vehicle that would be considered the most severe for the application. The speed and accelerator pedal position (APP) traces should be used to program the dyno to run those test portions. Ideally, a 1 Hz minimum trace should be used to program the dyno.

The idle portion of the test should use production/intent vehicle Park Idle speed and a vehicle representative engine load (including torque converter, accessory loads, etc.)

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 test duration should be determined by the appropriate Product Management Team (PMT).

4.2.2.1 Coolant Temperature Conditions. The coolant temperature should be measured near the thermostat as coolant is exiting the engine. This temperature should be controlled to production (intent) thermostat “start to open” temperature +11 ± 3 °C.

4.2.2.2 Oil Temperature Conditions. The oil sump temperature should be measured. If it is controllable, the engine sump temperature should be regulated to vehicle maximum temperature –22 °C (33 °F) ± 6 °C (10 °F) unless otherwise instructed by the test engineer.

4.3 Instructions.

4.3.1 Engine Break-In. The engine should be broke-in using the procedures provided by the Test Engineer.

4.3.2 Run any portion of the test, as required, to ensure that the automated test script will properly function once the engine is put on test.

4.3.3 Replace the EGR cooler, so that a new cooler is used at the start of test. Include all instrumentation as required by Section 5.1.1.

4.3.4 Complete a Performance Check at the start of test, once per 24 hour period, and at end of test. The Performance Check is defined in Appendix A3. Put the engine on test per the schedule in Appendix A1 (see also Section 4.2).

4.3.5 Record data per Table A1, including the parameters in Section 5.1.1.

4.3.6 Check oil level when the engine is shut down for shift changes, etc. Add oil only if the level is at or below the “ADD” (bottom of operating range) mark. Record the amount of oil added.

4.3.7 At least once per (8 hour) shift inspect the engine for oil and coolant leaks, loose fasteners and cracks in brackets, braces, wires, hoses, exhaust manifolds and engine exterior. Also, check dynamometer cell safeties/limits prior to restarting engine. Record any occurrences in the data sheets and repair or replace as necessary (document all part changes in the Part Change Summary sheet).

4.3.8 Perform maintenance per Section 4.4.

4.4 Maintenance Intervals.

4.4.1 Oil Change. This will vary with application, and engineering discretion should be used to determine the appropriate oil change interval.

4.4.2 Oil Filter Change. Conduct with oil change. Cut open and inspect the old filter for signs of problems.

Note: Save oil filter at least until next oil filter change or as indicated by Test Engineer.

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