



Validation of Turbo – Coke Temperature Safety Margin (Vendor Version)

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. The purpose of this test procedure is to verify that the temperatures inside the turbo bearing housing and turbo oil transfer pipes do not exceed coke-building temperatures under extreme operating conditions and after shutdown of the engine.

1.2 Applicability. This test procedure is valid for measurements of turbocharged spark ignition and compression ignition engines in test bench installations.

1.3 Remarks. In addition to the test methods described in this procedure, other critical driving conditions may be requested by the responsible engineer.

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

3 Resources

3.1 Facilities.

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. Fully capable engine dynamometer test cell with a combustion air supply capable of maintaining the standard air inlet pressure, temperature and humidity. The dynamometer shall be capable of testing to the maximum speed and torque of the engine under investigation.

3.3 Test Vehicle/Test Piece. Production or production intent parts shall be used whenever possible.

3.3.1 Turbocharger. The turbocharger hardware/installation shall be as close to production as possible. Thermocouples shall be mounted at points described as temperature critical for coolant water, oil, sealing, etc. by the turbo supplier. If no supplier information exists, thermocouples shall be mounted as shown in example in Appendix A, Figure A1.

3.3.2 Turbocharger Oil Feed and Drain Pipes (If Applicable). The turbo oil feed and drain pipes installation shall be as close to production intent as possible. Pipe skin thermocouples shall be mounted at points on the feed and drain pipes where the pipes are closest to hot surfaces. Hot surfaces are defined as surfaces that can exceed 500 °C during operation. Pipe shapes and relative locations vary widely. An example of a pipe is shown in example in Appendix A, Figure A2. This example pipe is close to the hot turbine housing in several locations and, therefore, requires several thermocouples.

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3.3.3 Turbocharger Heat Shield. If applicable, a production intent turbocharger heat shield(s) shall be installed for the duration of this testing.

3.3.4 Intake Air Condition. Intake air temperature, humidity and pressure should be maintained at values prescribed by test. In case the test cell has no intake air conditioning, it is very important to make a note and record the intake air temperature, pressure and humidity carefully.

3.3.5 Exhaust System. A production intent catalytic converter shall be used in the exhaust system to properly represent the thermal conditions during engine operation and hot soak. Exhaust backpressure should match that of the vehicle but can be simulated with gate valve or similar equipment.

3.3.6 Intercooler. Intercooler engines shall be tested with intercooling. The intended vehicle intercooler and piping can be replaced with a test bench system. If so, the pressure drop and temperature behavior inside the complete intercooler system where required, shall comply with the values stated in the specification for the complete vehicle application intercooler system. Heating/cooling effect on piping downstream the intercooler shall be considered. If vehicle data is not available, charge air temperatures downstream from the intercooler shall be set according to the values specified in Table 1.

Table 1: Intercooler Outlet Temperatures

Engine Speed (rpm)	Intercooler Outlet Temperature (Degrees Celsius)
1000	35
1500	40
2000	45
2500	50
3000	55
3500	55
4000	55
4500	55
5000	55
5500	55
6000	55

rpm Revolutions per Minute

3.3.7 Thermostat. In order to properly control the coolant temperature, the thermostat should be pinned open, and the engine coolant temperature controlled by the test cell system. The default setting is 95 °C coolant out. The primary goal is to maintain a stable thermal condition.

3.3.8 Oil Cooler. If an auxiliary oil cooler is used to cool the engine oil, care should be taken to match the pressure drop and temperature measured in the vehicle.

3.3.9 Coolant Overflow Bottle. To properly simulate the thermo-siphon effect during hot soak, a vehicle-representative coolant circuit with coolant bottle installed at a correct height shall be part of the test.

3.3.10 Cooling Fan. An auxiliary fan can be used for additional cooling of the engine on the dynamometer to protect components from damage due to exhaust heat. This fan must not be connected to the electrical system of the engine. The fan shall at most simulate driving conditions and not provide non-representative cooling to critical temperature measurement areas. The specification and location of the fan shall be documented.

3.3.11 Instrumentation. Suitable in range, size and accuracy to measure the parameters, which are required by the test to be performed. The fundamental parameters are listed in 5.1.1. For temperature measurements of both internal turbocharger and oil pipe(s) skin, generally type K thermocouples are preferred.

3.3.12 Calibration. Calibration affecting combustion shall be updated to the development status. Document all changes made to the calibration. Changes shall be kept to a minimum.

3.4 Test Time.

Calendar time: 0.5 day
 Test time: 2 h
 Coordination time: 2 h

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3.5 Test Required Information.

- Torque and power specification
- Specified coolant water thermostat opening temperature
- Maximum specified engine oil temperature

Note: Responsible Technical Team is to make sure that information is kept current.

3.6 Personnel/Skills. Test cell operator(s) trained in setup, use, and maintenance of test cell control and data acquisition systems.

4 Procedure

4.1 Preparation. Install internal combustion engine to dynamometer and complete functional checks to ensure correct performance of the cooling, lubrication, fuel, intake, exhaust and electrical systems. Initial engine break-in should also be performed prior to dynamometer testing.

4.2 Conditions.

4.2.1 Environmental Conditions. See following test conditions.

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.

4.2.2.1 Standard Atmospheric Conditions. Conditions to test:

- Inlet Air Supply Pressure: (100.0 ± 2.0) kPa
- Water Vapor Pressure: (1.0 ± 0.2) kPa
- Inlet Air Supply Temperature: (25.0 ± 2.0) °C

4.2.2.2 Exceptions. Exceptions for full load test and hot soak test:

- Coolant out temperature = Specified thermostat opening temperature +15 °C
- Engine oil temperature shall not exceed maximum specified by production intent type

For all other tests specified by test engineer use worst case scenario.

4.3 Instructions. The test is divided into three parts: (1) Full Load, (2) Hot Soak, and (3) Other critical scenarios (tests) unique to specific configurations defined by the responsible Technical Team.

4.3.1 Full Load.

4.3.1.1 Run engine at 1000 rpm.

4.3.1.2 Increase load to maximum specified load.

4.3.1.3 Reduce coolant water flow until specified coolant out temperature is reached.

4.3.1.4 When temperatures have stabilized ($\delta T/dt = < 1$ °C in 30 s), record all parameters (see 7.2)

4.3.1.5 Reduce load to safe level.

4.3.1.6 Repeat the test in engine speed steps by 1000 rpm and full load (peak power and peak torque) until maximum engine speed is reached. This is done at Wide Open Throttle (WOT) with the turbocharger on production intent calibration. If high temperatures appear, perform tests in smaller steps to find peak temperature at specific engine speeds. Tests can also be run at any other possibly critical engine speed as stated by the test engineer.

4.3.2 Hot Soak.

4.3.2.1 Run engine with maximum specified engine load at maximum power engine speed.

4.3.2.2 Reduce coolant water flow until specified coolant out temperature is reached.

4.3.2.3 When temperatures have stabilized ($\delta T/dt = < 1$ °C in 30 s), record all parameters.

4.3.2.4 Shut down the engine quickly (by switching the ignition key off).

4.3.2.5 Directly after shutdown, turn off all external cooling fans and exhaust evacuation fan.

4.3.2.6 Record all temperature parameters for 5 minutes after engine shutdown.

4.3.2.7 Check function of thermo-siphon effect, electrical pump or any other coolant device in cooling circuit.

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