



Underbody Exhaust Temperatures For Federal Chamber of Automotive Industries (FCAI) Compliance

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 evaluate the exhaust system in accordance with the Federal Chamber of Automotive Industries (FCAI) Australia Code of Practice for Underbody Exhaust System Surface Temperatures of Motor Vehicles.

1.2 Applicability. This test procedure applies to all underbody exhaust systems according to the following height criteria, where the heights are measured at curb mass:

- Vehicles other than off-road vehicles 300 mm or less above the ground.
- Off road vehicles 450 mm or less above the ground.

Refer to Appendix A and Appendix C for further definition of applicability to the underbody exhaust system.

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.

- FCAI (Australia) Code of Practice for Underbody Exhaust System Surface Temperatures of Motor Vehicles
- GM North American Operations Desert Proving Ground Thermocouple Handbook
- Vehicle Standard (Australian Design Rule Definitions and Vehicle Categories) 2005
- Vehicle Technical Specification (VTS)

3 Resources

3.1 Facilities. This test procedure can be executed on an outdoor test track or in a climatic wind tunnel with chassis dynamometer.

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.

3.1.3 Climatic Wind Tunnel. A Climatic Wind Tunnel with ability to provide a combined minimum vehicle speed and wind speed of 110 km/h, vehicle loading using a chassis dynamometer (typical minimum tractive force of 5000 N), and ambient temperatures of 20 °C to 30 °C. The tunnel shall provide representative airflow through the heat exchangers, under hood, and underbody of the vehicle. The climatic wind tunnel shall provide airflow through the heat exchangers, under hood, and underbody of the vehicle so as not to provide lower measured exhaust temperatures than those measured in an on road test.

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The chassis dynamometer shall have the front wheels rotating on rear wheel drive vehicles at the applicable road speed. Dynamometer loads shall be obtained from measured road or calculated coast down data with the applicable grade portion added.

3.1.4 On-Road Facility. An on-road test facility shall be equipped with a designated test location (e.g., circular track) with defined procedure, start and stop locations and an appropriate soak area. The test track shall have a hard surface of minimal gradient over its length. A wind break with a minimum of two (2) sides is required for the idle soak portion of the test. The wind break shall provide a wind velocity of 3 m/s maximum.

3.2 Equipment.

3.2.1 General.

3.2.1.1 Temperature measuring and recording equipment as described in Appendix A.

3.2.1.2 Measuring and recording equipment for the engine speed.

3.2.1.3 Use (Climatic Tunnel) Device for operation and adjustment of accelerator pedal.

3.2.1.4 Use (on road testing) Towing Dynamometer for setting vehicle load, vehicle speed and Decelerometer.

3.3 Test Vehicle/Test Piece. Vehicles equipped with an exhaust system and configured with appropriate vehicle content.

3.4 Test Time.

Calendar time: 2 days

Test time: 11 hours

Coordination time: 4 hours

3.5 Test Required Information. The following information shall be provided by the test requestor to the test engineer:

- Gross Vehicle Mass (GVM) shall be provided for the particular vehicle program and engine/exhaust configuration being tested (refer to 7.1 for more detail on GVM).
- The applicable test vehicle fuel(s), as defined in the Vehicle Technical Specification (VTS) shall be provided for the particular vehicle program (i.e., 91 Research Octane Number (RON) and/or 95 RON gasoline).
- Applicable vehicle run in procedure.

Note: Based on past program execution, 2000 kms break-in is sufficient for exhaust surface temperatures to stabilize. Each program will have a unique break in procedure (or distance) to achieve exhaust temperature stabilization. As a result, it is recommended that the break-in procedure be confirmed with the exhaust Design Release Engineer (DRE) and the test requestor.

3.6 Personnel/Skills. One (1) climatic tunnel operator and/or one (1) driver (if necessary) trained and proficient in operating the climatic wind tunnel or driving the procedure at the on-road facility. For all performance driving tests, the driver must be qualified and obtain the correct driving permits, as required by each test facility.

4 Procedure

4.1 Preparation.

4.1.1 The vehicle shall be equipped with devices according to 3.2 and Appendix A. Ensure that a front license plate or blank equivalent (size: country specified, per VTS) is installed. If the vehicle will be tested with camouflage, ensure that the airflow path to the heat exchangers, underhood, and underbody of the vehicle are not interfered with.

4.1.2 In addition to the temperature measuring locations listed in Appendix A, other locations that are considered critical temperature points shall be measured, as determined by the test engineer.

4.1.3 Prior to test, the powertrain and exhaust must be preconditioned by completing a vehicle run in procedure, as specified by the test requestor (see 3.5).

4.1.4 It is recommended to power check the engine prior to test. The engine or transmission shall not be tested if it has completed more than 50 000 km of total usage.

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4.1.5 Thermocouples shall be welded, or otherwise securely attached to the underside of horizontal and the forward facing surface of vertical sections of exhaust system or shields, where fitted, according to the following height criteria, where the exhaust surface heights are measured at curb mass (refer to Appendix A, Table A1):

- 300 mm for above the ground other than off-road vehicles.

or

- 450 mm above the ground for off-road vehicles.

4.1.6 Where the exhaust is routed above underbody shields, only the exhaust surface temperature below the applicable ground line and underbody shield shall be measured. See Appendix C, Figure C3.

4.1.7 Where the exhaust is routed above cross members (or equivalent), only exhaust surface temperature below the applicable ground line and cross member (or equivalent) shall be measured. Refer to Appendix C, Figure C4.

4.1.8 The location of exhaust surface thermocouples shall be approved by the Exhaust DRE, Subsystem Validation Engineer and Exhaust Development Engineer.

4.1.9 The thermocouple attachment method used to measure exhaust surface/shield, underbody shield or cross member shield temperature shall be that as specified in the GM North American Operations Desert Proving Ground Thermocouple Handbook.

4.1.10 If there is more than one (1) catalytic converter or particulate filter, each catalytic converter and particulate filter shall be measured at the applicable locations in Appendix A, Table A1. Refer to Appendix C, Figure C2 for an example of typical thermocouple locations.

4.1.11 The test vehicle shall have a representative calibration level of 80% or greater. Powertrain calibration levels of less than 80% are not a reliable indicator of exhaust surface temperatures.

4.2 Conditions.

4.2.1 Environmental Conditions. The test shall be executed at the following environmental conditions:

- Ambient temperature (On Road Test): 20 °C to 22 °C and ≥ 30 °C.
- Ambient temperature (Climatic Tunnel): 20 °C and 30 °C.
- Wind velocity: 3 m/s maximum.
- Precipitation: Zero.
- Road Conditions: Dry.

The point of measurement of the ambient temperature in the climatic tunnel shall be located so that it is unaffected by the thermal effects of the vehicle.

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 Where the vehicle has multiple axle drive capability, it may be driven by one (1) axle.

4.2.3 Transmission Gear.

4.2.3.1 Automatic Transmission.

4.2.3.1.1 For vehicles fitted with an automatic transmission, Drive (D) shall be selected. All possible transmission gears with D selected shall be tested for each test condition.

4.2.3.1.2 The automatic transmission gear to be used shall be established by moderately accelerating or decelerating to the applicable vehicle test speed, whichever method selects the transmission gear that results in the highest exhaust surface temperatures.

4.2.3.2 Manual Transmission.

4.2.3.2.1 For vehicles fitted with a manual transmission, the highest practical gear that can maintain the specified vehicle speed shall be selected.

4.2.4 Particulate Filter (PF) Equipped Vehicles.

4.2.4.1 Vehicles equipped with a Particulate Filter (PF) are required to run PF regeneration (where possible), as specified in 4.3.1 and 4.3.2.

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4.2.5 Test Fuel.

4.2.5.1 The test vehicle shall be operated on the test fuel nominated by the test requestor (see 3.5) that results in the highest exhaust surface temperatures.

4.3 Instructions.

4.3.1 Climatic Tunnel. Ensure the test vehicle is fitted with recording equipment according to Appendix A. Stabilize the tunnel until the required environmental conditions in 4.2 are achieved. Reference Table 1 or Table 2.

Table 1: Auto Air Conditioning (A/C) Conditions

Auto A/C Temperature Setting	Ambient Temperature (°C)
Maximum cold	20
Maximum blower speed	30
Outside air not in recirculation	

Table 2: Manual A/C Conditions

A/C and Blower Setting	Ambient Temperature (°C)
A/C on	20
Maximum blower speed	30

4.3.1.1 Drive the vehicle at 50 km/h and 7% road grade until the exhaust surface temperature is stable. Decelerate at approximately 3 m/s² until the vehicle is stationary. Idle with the transmission in neutral and zero wind velocity for 30 minutes. Record exhaust surface temperature at one (1) minute intervals during the first five (5) minutes and then at least each succeeding five (5) minutes. If all recorded temperatures have fallen to less than 300 °C, 15 minutes into the idle period, the test may be terminated.

4.3.1.2 When the test vehicle is fitted with a PF a regeneration cycle is required to be initiated at the end of stabilization at the designated operating conditions (e.g., 50 km/h and 7% road grade). When stabilization is achieved at the designated operating conditions, activate the PF regeneration using an appropriate diagnostic tool (i.e., TECH II). The regeneration shall be started so that there will be 350 s to 400 s remaining in the regeneration cycle at the beginning of the idle. The most effective method to do this is to monitor the regeneration counter in the vehicle diagnostic information. If this information is not available, it is acceptable to use the total time of regeneration as an estimate (e.g., if the total regeneration cycle is 14 minutes). The PF regeneration may be started 8 minutes prior to the idle.

4.3.1.3 Where the powertrain calibration of the test vehicle is such that it is not possible to initiate a PF regeneration cycle during the designated driving condition, the test result is valid without the execution of the PF regeneration cycle.

4.3.1.4 If the measured exhaust surface temperature profile, at any time during the test, is less than, but within, 38 °C of the maximum temperature profile in Appendix B, Figure B1, then testing at additional A/C settings is required for the 50 km/h 7% grade test condition. The additional A/C settings may result in higher underbody exhaust surface temperatures.

4.3.1.5 If additional A/C settings are required to be tested for the 50 km/h 7% grade test condition, these settings are to be established in consultation with the test requester, subsystem validation engineer, exhaust development engineer and exhaust DRE. These additional A/C settings can include any combination of the following:

- Auto Climate Control off.
- Auto Climate control set to 23 °C.
- Manual A/C and blower off.
- Manual A/C on and blower set to medium speed.

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4.3.1.6 The applicable vehicle test conditions in Table 3, other than 50 km/h and 7% road grade, shall be executed at the ambient temperature that resulted in the highest exhaust surface temperature during the 50 km/h and 7% road grade testing.

Table 3: Vehicle Test Conditions

Vehicle Type	Speed	Road Grade
All Vehicles	50 km/h	7%
Passenger Vehicles and Derivatives	110 km/h	0%
Commercial Vehicles	At the lesser of 110 km/h or 10 km/h below maximum speed	0%
Off Road	30 km/h	12%

4.3.1.7 Test the remaining applicable vehicle test conditions from Table 3 at the ambient temperature that resulted in the highest exhaust surface temperature from the previous testing at 50 km/h and 7% road grade. Refer to Appendix F, Figure F1 for more detail on the test sequence.

4.3.2 On-Road Facility.

4.3.2.1 Ensure the test vehicle is fitted with recording equipment according to Appendix A. At the applicable environmental conditions specified in 4.2.1 and the applicable vehicle test conditions outlined in 4.2.2, drive the vehicle at 50 km/h and 7% road grade until the exhaust surface temperature is stable.

4.3.2.2 Decelerate at approximately 3 m/s² until the vehicle is stationary in an area with zero wind velocity. Idle with the transmission in neutral for 30 minutes.

4.3.2.3 Record exhaust surface temperature at one (1) minute intervals during the first five (5) minutes and then at least each succeeding five (5) minutes. If all recorded temperatures have fallen to less than 300 °C, 15 minutes into the idle period the test may be terminated.

4.3.2.4 When the test vehicle is fitted with a PF, a regeneration cycle is required to be initiated at the end of stabilization at the designated operating conditions (e.g., 50 km/h and 7% road grade). When stabilization is achieved at the designated operating conditions, activate the PF regeneration using an appropriate diagnostic tool (e.g., TECH II). The regeneration shall be started so that there will be 350 s to 400 s remaining in the regeneration cycle at the beginning of the idle. The most effective method to do this is to monitor the regeneration counter in the vehicle diagnostic information. If this information is not available, it is acceptable to use the total time of regeneration as an estimate (e.g., if the total regeneration cycle is 14 minutes), the PF regeneration may be started 8 minutes prior to the idle.

4.3.2.5 If it is not possible to initiate a PF regeneration cycle during the designated driving condition, the test result is valid without the PF regeneration cycle.

4.3.2.6 If the measured exhaust surface temperature profile at any time during the test is less than, but within, 38 °C of the maximum temperature profile in Appendix B, Figure B1, then testing at additional A/C settings is required for the 50 km/h 7% grade test condition. The additional A/C settings may result in higher underbody exhaust surface temperatures.

4.3.2.7 If additional A/C settings are required to be tested for the 50 km/h 7% grade test condition, these setting are to be established in consultation with the test requester, subsystem validation engineer, exhaust development engineer and exhaust DRE. These additional A/C settings can include any combination of the following:

- Auto Climate Control off.
- Auto Climate control set to 23 °C.
- Manual A/C and blower off.
- Manual A/C on and blower set to medium speed.

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4.3.2.8 Test the remaining applicable vehicle test conditions from Table 3. Refer to Appendix F, Figure F1 for more details on the test sequence.

4.3.3 Heat Shield Evaluation. Where shields, shielding or guards are used to obtain acceptable surface temperature of exhaust system components, their design shall be such as will not assist the capture and build-up of flammable vegetation. Refer to Appendix D, Figures D1 through D3 for images of exhaust heat shielding that will not assist in the capture and buildup of flammable vegetation.

5 Data

5.1 Calculations.

5.1.1 Dynamometer Load Calculation. Dynamometer load calculations are required for simulating Grade Load (GL) and trailer GL conditions.

5.1.1.1 All vehicle types: 50 km/h at 7% GL at GVM.

5.1.1.2 Passenger cars: 110 km/h road load.

5.1.1.3 Commercial vehicles: The lesser of 110 km/h or 10 km/h below maximum speed at road load.

5.1.1.4 Off-road vehicles: 30 km/h at 12% GL at GVM.

5.2 Interpretation of Results. The surface temperatures of underbody exhaust components or shields, if installed, shall not exceed the maximum temperature shown in Appendix B, Figure B1, where ground cover may reasonably be expected to be contacted by the exhaust during the operation of the vehicle. Refer to Appendix C, Figure C1 for an example of typical ground cover.

5.2.1 This requirement applies at the following heights measured at curb mass:

- Vehicles other than off-road vehicles 300 mm or less above the ground.
- Off-road vehicles 450 mm or less above the ground.

Refer to Appendix C for more detail on thermocouple location.

5.2.2 A margin from the test vehicle(s) exhaust surface temperature to Appendix B, Figure B1 is required for the final certification test to allow for the following:

- Production (vehicle to vehicle) variation.
- Test uncertainty.

Refer to Appendix E for the required general margin of the final certification test.

5.2.3 With sufficient exhaust surface temperature, test results, and statistical analysis the margin of the final certification test can be varied from what is listed in Appendix E, Table E1.

5.3 Test Documentation. With reference to this test procedure, the results of the measurements and photographs of all thermocouples shall be presented in an evaluation report with a report number.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary.

Grade Load: The force required to operate a vehicle on stretches of road along which the slope changes in the direction of travel.

Gross Vehicle Mass: A value specified by the manufacturer as the maximum load carrying capacity of the vehicle, as measured at the tire-ground interfaces. It is the sum of:

- Curb Mass.

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