



Powertrain Cooling and Thermal Performance for Passenger Vehicles

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 determine the powertrain cooling temperatures (coolant, engine oil, and transmission oil) and thermal temperatures (underhood and underbody components affected by powertrain generated heat) for the conditions specified in the Vehicle Technical Specifications (VTS).

1.2 Applicability. This procedure is applicable for all passenger vehicles and multipurpose vehicles. The procedures are only applicable for properly configured vehicles. The performance or specialty vehicle procedures shall be run only on vehicles configured with all the standard and optional equipment required to perform the task listed.

1.3 Remarks. This test procedure is used to validate the powertrain cooling and thermal capability for a vehicle program. The temperatures measured are compared against the limits defined in the VTS, Subsystem Technical Specifications (SSTS), or Component Technical Specifications (CTS). Performance or specialty vehicle conditions are additional vehicle conditions required beyond the standard conditions of GMW14555. It is recommended that the standard vehicle test conditions be completed prior to running the performance/specialty vehicle conditions.

The results of this procedure support GSO-42 General Requirements: Cooling System and Exhaust System.

2 References

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

2.1 External Standards/Specifications.

GSO-42 SAE J2807

2.2 GM Standards/Specifications.

GMW14167	GMW14193	GMW14961	GMW17168
GMW14191	GMW14328	GMW15445	
GMW14192	GMW14960	GMW15730	

2.3 Additional References.

- Component Technical Specification(s) (CTS).
- Owner's Manual.
- Program Powertrain Cooling VTS.
- Subsystem Technical Specification(s) (SSTS).
- Vehicle Technical Specifications 3.2.1.5.4.

3 Resources

3.1 Facilities. This procedure is facility independent. Detailed information is provided to execute each test condition. However, this information may not be sufficient to ensure that the test results from each facility are equivalent. It is the responsibility of each facility to define the steps for executing this procedure based on the

GM Confidential

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January 2016

Page 1 of 58

capability of their facility with consistency of test results from facility to facility being the primary objective. This includes defining procedure start points, end points, and specific locations or tunnel procedures for running events such as soaks or idles, etc. This procedure can be run at an on-road test facility or a climatic wind tunnel facility with the following capabilities.

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. Climatic Wind Tunnel with ability to provide the vehicle speed (typical minimum 160 km/h), wind speed (typical minimum 160 km/h), vehicle loading using a chassis dynamometer (typical minimum tractive force of 5000 N), and ambient temperature (controlled within a range of ± 1 °C) required for each condition. The tunnel should provide representative airflow through the heat exchangers, underhood, and underbody of the vehicle. It is recommended that the wind tunnel have the ability to control the humidity of the air and to provide a simulation of solar loading on the vehicle.

3.1.3.1 Climatic Wind Tunnel Limitations. Underbody temperatures measured in the wind tunnel may have differences between on-road temperature measurements. The comparison of underbody temperature measurements and on-road measurements, for each facility, should be understood when making program decisions. The climatic tunnels should also not be used for the validation of rear fascia temperatures and city traffic power steering system fluid temperatures.

3.1.3.2 Climatic Wind Tunnel Solar. The ability to provide the solar intensity specified is recommended. Having solar capability is not required if in the judgment of the responsible engineer it would not adversely affect the test results.

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 or wind break. A city traffic pad area is recommended but is only required when validating city traffic power steering system fluid temperatures. A wind break with a minimum of two sides is required. The vehicle should always be parked on the downwind side.

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 Pressure measuring and recording equipment as described in Appendix A.

3.2.1.3 Measuring and recording equipment for the engine speed.

3.2.1.4 Measuring devices for mechanical fan and prop shaft speed (if applicable).

3.2.1.5 Measuring and recording equipment for voltage and current for compartment blower(s), battery(s), and engine cooling fans (if applicable).

3.2.1.6 Device for measuring quantity of coolant required (in case of coolant loss during soak test).

3.2.1.7 (Wind Tunnel) Device for operation and adjustment of accelerator pedal.

3.2.1.8 (On-road testing) Towing Dynamometer for setting vehicle load. Several load classes are available. Only the appropriate load class should be used.

3.2.1.9 Power Take Off (PTO) Testing Load Absorbing Equipment: For the PTO application testing, a means for applying loading to the vehicle in order to simulate PTO operation must be provided (e.g., dynamometer, actual PTO appliance). The load absorbing equipment should have adequate control as to be able to accurately perform the testing in this procedure. An appropriate means for measuring and recording the load applied to the vehicle is required.

3.3 Test Vehicle/Test Piece. Passenger vehicles equipped with liquid cooling system and configured with appropriate vehicle content.

3.4 Test Time. See 4.3.

3.5 Test Required Information. Test conditions as specified by the VTS. Transmission gear (for maximum speed, some engines have a torque curve such that maximum speed is achieved at lower than highest gear). Some or all of the following information will be needed to set the vehicle conditions and loading per 5.1.1: Gross

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January 2016

Page 2 of 58

Documents
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Vehicle Mass Ratings (GVMR) and Gross Combined Mass Rating (GCMR), inputs for load calculations, engine maximum power and torque, engine maximum rpm, expected maximum vehicle speed, and trailer drawbar loads (or windage) information from Appendix F.

3.6 Personnel/Skills. One (1) climatic tunnel operator and/or one 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 dictated by each test facility.

4 Procedure

4.1 Preparation. The vehicle shall be equipped with devices according to 3.2 and Appendix A. Ensure that a front license plate or blank equivalent (size is country specified per VTS) is installed. If the vehicle will be tested with camouflage, ensure that the airflow paths to the heat exchanges, underhood, and underbody of the vehicle are appropriate.

Prior to test, the powertrain must be preconditioned per one of the following:

- **Engine Heat Rejection Test 9.**
- **Vehicle break-in procedure.**
- **At least 3000 km of general usage.**

It is recommended to power check the engine. The engine or transmission should not be tested if it has > 50 000 km of total usage.

4.1.1 Calibrated Pressure Cap. Use of a calibrated pressure cap set at minimum pressure relief value is recommended.

4.1.2 Coolant. All test conditions must use the release coolant and coolant to water ratio.

4.1.3 Deaeration. Coolant system should be deaerated to achieve the released coolant fill. Use service fill procedure plus two thermal cycles for vehicles not equipped with surge tanks.

4.1.4 Thermostat. Use of a calibrated thermostat set minimum stroke and at maximum temperature/set point opening value is recommended.

4.1.5 Fan Clutch (if equipped). Use of a fan clutch meeting the required performance when tested per GMW14328, GMW14960, or GMW14961 is recommended.

4.1.6 Heat Exchangers. Use of a radiator, condenser, charge air cooler and oil coolers with the required performance values (heat rejection and pressure drop) when tested per GMW14193, GMW14192, GMW14191, or GMW14167 respectively is recommended.

4.1.7 Powertrain Calibration Level. Use vehicles with vehicle calibration levels at 80% or greater for validation, 99% or greater for hot mode validation.

4.1.8 Vehicle Fluid Levels. Use the released fill levels. Transmission fluid should be set to maximum fill level.

4.1.9 Electrical Power Supply. All vehicle electrical systems shall be supplied by the internal vehicle power supply. Instrumentation can be powered by non-vehicle power supply when possible.

4.1.10 Vehicle Ballasting (On-road Testing). Ballast the vehicle per GMW15445 or equivalent to achieve the trim height for the GVMR or GCMR specified.

Note: Ballasting should be done once all safety equipment such as fire extinguishers and roll cages, if required, are installed.

4.1.11 Frequent Stop Warning Lights (On-road Testing). If the city traffic procedure will be conducted on a circular track, install frequent stop warning lights if required by the facility.

4.1.12 Specialty Equipment. The test vehicle shall be equipped with all required specialty vehicle equipment. These can include, but are not limited to, additional safety equipment, race track tires, high performance brakes, high performance brake fluid, police light bars (when appropriate), police brush guards (when appropriate), snow plow (or simulated plow), additional liquid cooling systems for PTO vehicles, special vehicle calibrations.

4.1.12.1 Fire Extinguisher System.

4.1.12.1.1 Fire Extinguisher (Portable). All vehicles shall also be fitted with portable, hand held fire-extinguishing system of at least 1.5 kg capacity, easily accessible to the driver on board or by a helper outside the vehicle.

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January 2016

Page 3 of 58



Documents
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4.1.12.1.2 Fire Extinguisher (Fixed). All vehicles shall be required to be fitted with a permanently mounted, plumbed in fire-extinguishing system of at least 4 kg capacity, at least half of which must be placed forward of the engine, but to the rear of the foremost pick-up points of the front suspension. The system must include a manual triggering device, operable by the driver on board or by a helper outside the vehicle, the location of which must be indicated by a letter "E" in a red circle. The operating system must be designed so that even if the battery of the car is inoperative, the extinguisher will still function.

4.1.12.2 Safety Cage. The installation of a safety cage is recommended for all vehicles undergoing continuous racetrack laps at high speed. Safety cages must be designed and made so that, when correctly installed, they substantially reduce body deformation and so reduce the risk of injury to occupants. The essential features of safety cages are sound construction, designed to suit the particular vehicle, adequate mountings and a close fit to the body shell. Tubes must not carry fluids. The safety cage must not unduly impede the entry or exit of the driver and co-driver. Members may intrude into the occupant's space in passing through the dashboard and front side-trim, as well as through the rear side-trim and rear seats. The rear seat may be folded down. Longitudinally, the safety cage must be entirely contained between the top mounting points of the front and rear suspension that carry a vertical load (springs and suspension dampers).

4.2 Conditions. Special Considerations. The conditions identified in Table 1 and Table 1a were chosen because they historically represented the needed capacity for the specified regions. It is the intention of these tests to be capacity setting conditions for both powertrain cooling and thermal components. There are several variables that directly affect the severity of the condition specified. The primary variables are ambient temperature, vehicle speed, transmission gear state, transmission torque converter state, A/C system state, and engine cooling fan state. The listed conditions are required at a minimum, but it is expected that if a variation in one of these variables is a reasonable possible selection, the effect of this modified condition should be evaluated. More specific considerations for these variables are given below.

4.2.1 Environmental Conditions. The test shall be run at the environmental conditions in Table 1. For on-road testing, unless specified otherwise, the ambient temperature at the start of the test shall be within $\pm 3^\circ\text{C}$ of the temperature listed in Table 1. The test shall be conducted under full sun and with winds $< 24\text{ km/h}$. The solar load listed in Table 1 is the minimum acceptable value. The solar load should be set to 1000 W/m^2 for 35°C or higher ambient conditions for facilities with variable solar load capabilities (e.g., Climatic Wind Tunnels).

4.2.1.1 Mid-Ambient Conditions (Fan State Effect). The temperature of underhood components near the exhaust system can be highly dependent on the engine cooling fan state. If components are near to the exhaust system and the temperature of the components is close to the temperature limits with the engine cooling fan on high, it is recommended to repeat the condition at a lower ambient, or with a modified Idle/soak, where the fan state would be lower (or potentially off). The choice of the appropriate ambient temperature or method to modify the idle/soak are dependent on the program cooling fan strategy (set points). The intention is to modify the condition to have the severest possible exhaust temperatures with the fan at a lower state or off. For this reason, the choice of mid-ambient temperatures are left to the program engineer. Known conditions or modified conditions that should be considered are:

- City Traffic. Recommendation for mid-ambient temperatures to check are given in 4.3.1, but the intention is pick an ambient which results in the highest exhaust temperatures with the fans on low or off.
- Replacing the soak with an extended idle or vice versa. The ambient should be chosen which results in the worst case fan states.
- Replacing a soak with fan after-run with a soak with no fan after-run. This can possibly be achieved by lowering the ambient or aborting a high load test event just prior to triggering the fan after-run threshold.

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.

4.2.3 Correcting Temperature Measurements for Ambient. The temperature results from on-road testing shall be corrected degree for degree to the ambient temperature specified in Table 1. Example, if Table 1 lists 38°C and the test was conducted at 36°C ; 2°C should be added to the temperature measurements. If the ambient temperature changes measurably during the test, proper judgment should be used when correcting temperatures with the ambient temperature during the main part of the test (e.g., grade load, trailer grade load) used for the correction.

4.2.4 Vehicle Climate Control Settings (Front and Rear if Equipped).

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January 2016

Page 4 of 58



Documents
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The following A/C settings should be used unless specified in the test conditions.

- **Temperature:** A/C Full Cold.
- **Blower Setting:** Medium (approximately 6 V) for 30 °C or lower and High (approximately 14 V) for all other ambient conditions except as noted.
- **Air Direction:** Direct instrument panel A/C outlets away from floor or tunnel area.
- **Inlet Air Mode:** Outside Air Mode (OSA) should be selected unless otherwise noted in the test condition (see 4.2.6 for additional details).
- **Compressor:** On.

4.2.5 Blower Settings. For medium blower settings, the blower shall be put on the setting which results in the blower voltage being closest to 6 V.

4.2.6 Outside Air (OSA) vs. Recirculation. The initial A/C setting shall be made per 4.2.4. If the A/C, full cold, OSA setting results in the vehicle immediately entering recirculation mode, the temperature setting shall be increased in 1 degree increments until the vehicle maintains OSA. However, if during the testing the vehicle switches to recirculation, no action is required to force the vehicle back into OSA.

4.2.7 Transmission Gear. Except as noted, the transmission gear should be Drive for an automatic transmission (AT) or the highest possible gear that can maintain the specified vehicle speed for manual transmissions. If excessive gear shifting is required to maintain vehicle speed, the lower transmission gear should be manually selected (also see note on vehicle speed in 4.2.9). Excessively is defined as more than four downshifts/upshifts in 1 km. For manual transmissions, if two gears are possible selections from a typical driver, the more probable gear should be selected.

If both gears are equally likely, both should be considered, in accordance with other constraints of the condition. The gear which results in the more severe performance should be selected for validation purposes. If the severity of the results varies by vehicle systems, both gear choices should be run.

If the vehicle has tap mode, or other similar driver selectable gear shifting, the effect of manually selecting gears using tap mode must be considered. The choice of gears using tap mode should follow the same process as manual transmissions as described previously in 4.2.7.

If the vehicle has tow/haul mode, it should be selected if it is recommended in the owner's manual for the operating condition being tested.

4.2.7.1 Transmission Gear (Hybrid Vehicle Coast Down). When coasting down hybrid vehicles, it may be necessary to make sure the vehicle has a true neutral gear setting. If there is not a true neutral gear setting, it may be necessary to use the vehicle calibration to put the vehicle in a coast mode.

4.2.8 Transmission Gear (Specialty Conditions). For all specialty tests, gear selection is left to the discretion of the driver or test engineer. When appropriate, the gear selection shall be done using the procedure outlined in 4.2.7. However, for all specialty tests, it is recognized that the gear selection is especially driver (e.g., race track or police) or condition (e.g., PTO operation) dependent.

4.2.9 Vehicle Speed. Except as noted, if after selecting the appropriate gear(s) the vehicle cannot maintain the specified speed; run the vehicle at Wide Open Throttle (WOT). Allow the vehicle speed to decrease until a stabilized speed can be maintained. For automatic transmission, if because of vehicle calibration, the gear selection is sensitive to the speed specified, it is acceptable to adjust the speed up to ± 10 km/h from the vehicle speed specified to determine the effect on temperatures. It is also acceptable to consider the effect of switchbacks for hill procedures. The test method for simulating switchbacks is left to the test engineer.

4.2.9.1 Vehicle Speed – Active Safety Features. For vehicles equipped with active safety features such as object detection, auto-braking, lane departure, it may be necessary to disable these features when testing in a wind tunnel facility because of detection issues with the tunnel walls and equipment.

4.2.9.2 Vehicle Speed – Braking. For vehicles where the braking activity is an integral part of the temperature performance (e.g., hybrid vehicles with E-stop), it will be necessary to actuate the brakes by either driving the vehicles or using a throttle controller with active braking.

4.2.10 Battery Temperature Measurements (Global Sequence Test Only). If battery temperature measurements are required, the battery should be a minimum of 80% state of charge with the electrolyte temperature within ± 3 °C of ambient at the start of test.

GM Confidential

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January 2016

Page 5 of 58

Documents
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4.2.11 Data Recording. Data recording shall start at the beginning of the preconditioning and stop at the end of test.

4.2.12 Vehicle Cool Down Procedure. After completing any test condition, the vehicle should be cooled so that the appropriate vehicle temperatures are less than the stabilized preconditioning temperature for the next condition. The cool down method is left to the test personnel.

4.2.13 Abort Criteria. At times, it may be necessary to terminate the test due to a vehicle malfunction or excessively high temperatures. Determination of abort criteria are left to test personnel with safety being the primary consideration.

4.2.14 Particulate Filter (PF) Equipped Vehicles. Vehicles equipped with a Particulate Filter may be required to run a Particulate Filter regeneration as specified in conditions 21 through 23. For conditions 21 and 22, when regeneration is required, the procedure in 4.2.14.1 should be used.

4.2.14.1 Near the end of the designated schedule (e.g., city cycle) activate the PF regeneration (Homologation Regeneration) using an appropriate diagnostic tool ("TECH II"). The regeneration should 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. However, it should be noted that for transient conditions, such as city traffic, the regeneration counter time and clock time may not match. If it is the case that the total regeneration cycle is near to or shorter than 350 s, it is the intention of the procedure to make sure the exhaust system is up to temperature and maximize the available time during the idle portion of the test.

4.2.14.2 The recommended soot loading of the PF should not exceed 100%. If the soot loading is < 100%, it is not required to soot load the PF prior to running the schedule. For condition 23, a modified regeneration calibration must be supplied by GM Powertrain to simulate the effects of a fully loaded particulate filter.

4.2.15 Active Aerodynamic Shutters. (Controlled blockage of front end airflow for enhanced drag coefficient.) Most of the conditions in Table 1 will result in shutters open conditions. Special attention should be paid to ensure that the active aerodynamic shutters are behaving as expected.

4.2.15.1 Active Shutter Required Conditions. In addition to the standard Global and regional specific conditions, for vehicles with shutter systems the Mid-Ambient tests for Condition 1 along with the shutter specific Conditions 25 and 26 are required.

4.2.15.2 Shutter Calibration Considerations. The existing required conditions are based on the 2015 calibration of shutter systems. It is likely that the strategy for shutter calibration may change in the future. Consideration should be given to each program specific calibration. Additional conditions may be needed if situations occur where the shutters may be closed in conditions where they are open today.

Table 1: Vehicle Test and Ambient Conditions by Region

Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
Global Sequence Test (Part 1 + Part 2 + Part 3)					
<u>Part 1</u> Rural Highway, City Traffic, Idle 20 minutes					

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Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
<u>Part 2</u> 50 km/h, 7.2% GVMR, 25 km, Soak <u>Part 3</u> 155 km/h, 50 km, Idle 30 minutes NOTE: The Global Sequence Test is intended to be run as a continuous test (Part 1 + Part 2 + Part 3) but it is acceptable to run the individual parts for development testing. These should be listed as Condition 1.1, Part 1					
Condition 1.1 – Global Sequence 38 °C	38 °C 40% 600 (Minimum on Road)/1000 (CWT) W/m ²				
Condition 1.2 – Global Sequence 25 °C	25 °C A/C Off 40% 600/600 W/m ²				
Condition 1.3 – Global Sequence	30 °C A/C Auto 22 °C or Full Cold, 6 V Blower (Manual Systems) 40% 600/600 W/m ²				
Condition 1.4 – Part 1 – RL + City Traffic + Idle at 43 °C	43 °C 30% 600/1000 W/m ²	N/A	43 °C 30% 600/1000 W/m ²	N/A	N/A
Condition 1.5 – Part 1 RL + City Traffic + Idle at 43 °C	N/A	N/A	N/A	N/A	46 °C 10% 600/1000 W/m ²
Condition 2.1 – High Ambient Minimum Speed Ratio	38 °C 40% 600/1000 W/m ²				
Condition 2.2 – Moderate Ambient Minimum Speed Ratio	15 °C 30% 600 W/m ²				

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January 2016

Page 7 of 58



Documents

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Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
Condition 3 90 km/h 7.2% GVMR + Soak	N/A	38 °C 40% 600/1000 W/m ²	N/A	38 °C 40% 600/1000 W/m ² (Australia, China, and South America Only)	N/A
Condition 3.1 90 km/h 7.2% GVMR + Soak	46 °C 10% 600/1000 W/m ²	N/A	N/A	N/A	N/A
Condition 3.2 Jabel Hafeet - 7.2% GVMR + Soak	N/A	N/A	N/A	N/A	46 °C 10% 600/1000 W/m ²
Condition 4 90 km/h Davis Dam GCMR + Soak + WOT drive away	43 °C 30% 600/1000 W/m ²	N/A	N/A	N/A	N/A
Condition 5 90 km/h, GCMR Stovepipe + Idle 15 minutes	46 °C 10% 600/1000 W/m ²	N/A	N/A	N/A	N/A
Condition 6 50 km/h 7.2% GVMR, Failed Plug + Soak	38 °C 40% 600/1000 W/m ²				
Condition 7 12%, A/C Off, 12 km GCMR,	25 °C 30% 500/500 W/m ² (CAC Sizing)	25 °C 30% 500/500 W/m ²	25 °C 30% 500/500 W/m ² (CAC Sizing)	25 °C 30% 500/500 W/m ²	25 °C 30% 500/500 W/m ²

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January 2016

Page 8 of 58



Documents

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Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
< 55 km/h + Idle 2 minutes + Soak				(CAC Sizing)	(CAC Sizing)
Condition 7.1 16%, A/C Off, 12 km GVMR, < 55 km/h + Idle 2 minutes + Soak	25 °C 30% 500 W/m ² (Non-Trailing CAC Sizing)				
Condition 8 12%, 12 km GVMR, + Soak < 70 km/h A/C On	N/A	30 °C 30% 500/500 W/m ²	30 °C 30% 500/500 W/m ² (Thailand Only)	N/A	N/A
Condition 9 80 km/h 6% GCMR 13 km + Idle	N/A	30 °C 30% 500/500 W/m ²	N/A	N/A	N/A

GM Confidential

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January 2016

Page 9 of 58



Documents

Document Sharing Hub

Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
Condition 10 Maximum Speed Test	38 °C 40% 600/1000 W/m ² (Performance Vehicles. Maximum Speeds > 200 km/h Only)	38 °C 40% 600/1000 W/m ²	N/A	N/A	N/A
Condition 10.1 Maximum Speed Test – India and Thailand	N/A	N/A	43 °C 30% 600/1000 W/m ² (India and Thailand Only) (Vehicle Maximum Speed < 180 km/h only)	N/A	N/A
Condition 10.2 Maximum Speed Test – Middle East	N/A	N/A	N/A	N/A	46 °C 10% 600/1000 W/m ²
Condition 10.3 Maximum Speed Test – Global Durability	38 °C 40% 600/1000 W/m ²				
Condition 10.4 Maximum Speed Test – CAC Sizing	25 °C 30% 500/500 W/m ²				
Condition 11 40 km/h, 7.2% GCMR for 10 km + Idle	N/A	N/A	33 °C 40% 600/600 W/m ²	33 °C 40% 600/600 W/m ² (Except South America)	N/A

GM Confidential

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January 2016

Page 10 of 58

Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
Condition 11.1 40 km/h, WOT (Maximum 16%) for 10 km + Idle	N/A	N/A	N/A	33 °C 40% 600/600 W/m ² (China Only)	N/A
Condition 12 20 km/h, 6% GCMR 30 minutes + Soak	N/A	N/A	N/A	38 °C 40% 600/1000 W/m ² (South America only)	N/A
Condition 24 60 km/h Colonia Tovar GVMR for 12 km + Soak	N/A	N/A	N/A	30 °C 30% 500/500 W/m ² (Venezuela Only)	N/A
Condition 13 115 km/h, WOT + Idle	38 °C 40% 600/1000 W/m ² (Truck Only)	N/A	N/A	N/A	N/A
Performance Driving					
Condition 14 Race Course – Press Show (VTS to specify Course. Example MRC, Grattan)	30 °C ≥ 600 W/m ² A/C Auto 22 °C				
Condition 15 Race Course – Session (VTS to Specify Course. E.g., Nurburgring 3 laps, MRC 7 laps)	30 °C ≥ 600 W/m ² A/C Off (unless specified in VTS)				

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January 2016

Page 11 of 58

**Documents**

Document Sharing Hub

Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
Condition 16 Race Course – Tank of Fuel (VTS to Specify Course. E.g., MRC, Nurburgring)	30 °C ≥ 600 W/m² A/C Off (unless specified in VTS)				
Specialty Police Tests (Development Only) Note: Police programs have specific validation requirements for each market/region. See Appendix H for examples of Police Validation tests					
Condition 17 Race Course - Police Car session	35 °C ≥ 600 W/m²	N/A	N/A	N/A	N/A
Condition 18 High Speed Pursuit Test	35 °C ≥ 600 W/m²	N/A	N/A	35 °C ≥ 600 W/m²	N/A
Miscellaneous Specialty Tests					
Condition 19 PTO Applications (e.g., Fire Truck) Test Procedure	38 °C ≥ 600 W/m²	N/A	N/A	N/A	N/A
Condition 20 Snow Plow Test Procedure	1.7 °C Solar Not Required	N/A	N/A	N/A	N/A
Particulate Filter Regeneration					
Condition 21 100 km/h GCMR + Idle w/PF Regeneration	38 °C 40% 600/1000 W/m²				
Condition 22 20 km/h GVMR + Idle w/PF Regeneration	38 °C 40% 600 W/m²				
Condition 23	25 °C to 30 °C Solar N/A				

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January 2016

Page 12 of 58



Documents

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Condition	North America (United States, Canada, Mexico, South Africa, Israel - GMNA-based vehicle)	Europe (Israel – GME-based vehicle)	GMIO Hot: India, Cambodia, Laos, Thailand, Vietnam, North Africa	GMIO Moderate: Australia, China, Japan, Korea, Rest of AP, South America	GMIO Middle East Operations, Rest of Middle East
PF Service Regeneration					
Vehicle Shutter Conditions					
Condition 25 Shutter Closed 120 km/h GVMR, A/C Off	25 °C 30% 500/500 W/m²				
Condition 26 Shutter Winter Grade Load/Trailer Grade Load	10 °C (or Ice mode set point) 30% 500/500 W/m²				
Condition 27 Hydraulic Power Steering Cooler Sizing Procedure	38 °C 40% 600/1000 W/m²				

AP Asia Pacific
CAC Charge Air Cooler
CWT Climatic Wind Tunnel
GMIO GM International Operations
MRC Milford Race Course
N/A Not applicable
RL Road Load

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January 2016

Page 13 of 58



Documents

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Table 1a: Special Considerations - Global and Regional

Global Considerations	
1.	Ambient Temperature Range (see 4.2.1). $\pm 3^{\circ}\text{C}$ from the target is the acceptable temperature range for on road testing.
2.	Solar Load in the CWT (see 4.2.1). When testing in a CWT a 1000 W/m^2 should be used in place of 600 W/m^2 for ambient temperatures of 35°C or higher unless otherwise noted.
3.	Vehicle Speed (see 4.2.9). $\pm 10\text{ km/h}$ is the acceptable range if the target speed is sensitive to gear selection (i.e., if the target speed is 90 km/h , the vehicle should pass in range of 80 km/h to 100 km/h). This does not include WOT operation. For WOT operation, the speed the vehicle can achieve at WOT is acceptable even if it is more than 10 km/h lower than the target speed. It is also acceptable to simulate the effect of switchbacks on hill procedures. The procedure for this is left to the test engineer.
4.	Gear Selection – (see 4.2.7). It is important to understand on each test condition all the possible gear choices. These include not only calibratable gear shifts and modes (e.g., tow haul, sport mode), but also, driver selectable gear choices include manual shift modes (e.g., tap shift).
5.	Idle vs. Soak (see 4.2.1.1). The listed after event must be considered, but it is acceptable to consider the effect of an idle vs. soak or vice versa.
6.	Cooling Fan Effect (see 4.2.1.1) a. Fan After-run - If the fan after-runs after the engine is turned off, a test should be conducted to lower the ambient or stop a hill test early to consider the engine off soak temperatures without fan after run. It is acceptable to consider different requirements for the two tests. b. Mid Ambient effect – If component temperatures are marginal to requirement, Condition 1 should be rerun at an ambient condition where the fan state would be low or off. Recommendation 25°C A/C off or 30°C A/C Auto. Mid-ambient conditions are required for vehicles with grille shutter systems (see 4.2.15.1).
7.	Soak effect of ambient airflow. During an engine off soak event, especially on engines with turbo charging, special consideration should be given to the effect of airflow around the vehicle during soaks. It is often the case that changes in the flow around the front of the vehicle can significantly affect temperatures in local parts of the underhood of the vehicle, especially in locations directly downstream of the exhaust system.
8.	For the purposes of this procedure, when a vehicle is not rated to tow a trailer, GCMR should be set to GVMR for conditions defined as continuous or excursion in the VTS. For conditions defined as extreme event in the VTS, GCMR should be set to GVMR + 454 kg . If because of trailer loading specifications (e.g. SAE J2807), the calculated GCMR of a vehicle is less than the GVMR of a vehicle, GCMR of the vehicle should be set to GVMR for the purposes of GMW14555.
9.	Hybrid Vehicle Coast Down. When coasting down hybrid vehicles, it may be necessary to make sure the vehicle has a true neutral gear setting. If there is not a true neutral gear setting, it may be necessary to use the vehicle calibration to put the vehicle in a coast mode.
North America	
1.	Non Trailering Vehicles. For vehicle programs without trailers, Condition 4 is generally not required.
Europe	
1.	None.
GMIO	
1.	Countries defined as GMIO Hot vs. Moderate. - Specific countries are defined in each category. For countries not listed, GMW15730 should be used to determine which category the country falls in. Where GMW15730 is required, the country should be treated as GMIO Hot. Countries not listed in GMW15730 should be treated as GMIO Moderate.
2.	Condition 24 Colonial Tovar is Required for Venezuela Only.

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3. Condition 3 at 46 °C for Middle East Operations simulates Jabel Hafeet. The variable speed profile defined should be considered. However, based on the vehicle program and customer expectations, it may be appropriate to consider a more aggressive vehicle speed profile. These profiles shall be determined by the program team.

4.3 Instructions. A vehicle program may not need to run all of the conditions of this procedure. The required conditions and requirements (continuous, excursion, extreme event) are dictated by the program VTS.

4.3.1 Condition 1.1 through 1.5 - Global Sequence Procedure. Execute the procedure at the ambient temperature, humidity, and solar intensity specified in Table 1. The global sequence parts are intended to be run sequentially to address time at temperature of components. However, if time at temperature is not required, it is acceptable to run the parts individually. When the VTS defines a condition as required for a region (e.g., city traffic) all of the Condition 1 versions should be considered (e.g., city traffic for GMNA should consider 1.1, 1.2, 1.3, and 1.4).

4.3.1.1 Part 1 (Warm Up + Rural Highway + Global City + Idle).

4.3.1.1.1 Rural Highway. Warm up the vehicle by running the vehicle at 100 km/h at GVMR for 24 km. Run the facility rural highway procedure. The facility rural highway procedure shall be equivalent to the procedure described in Appendix D. It shall be 23 minutes to 25 minutes in length. It shall have a target average speed of 44 km/h. It shall contain accelerations and decelerations between 50 km/h and 80 km/h. It shall contain a three minute idle (in Park for automatic transmissions and Neutral for manual transmission) with a moderate acceleration to 80 km/h in the last half of the procedure.

4.3.1.1.2 City Schedule. Run the facility city traffic procedure. The city traffic procedure should be equivalent to the global durability city traffic schedule. It shall be 50 minutes to 55 minutes in length. It shall be divided into two parts with a three minute engine off soak in the middle. It must contain stops and accelerations. It shall have an average target speed of 12 km/h. If power steering system fluid temperatures are being validated, it must contain both right hand and left hand steering maneuvers. An example city traffic course is shown in Appendix E.

4.3.1.1.3 Idle in Drive – 20 Minutes. Proceed to the city traffic designated idle location. The total time to reach the location shall not exceed five minutes. Decelerate the vehicle to 0 km/h. Idle the vehicle for 20 minutes in Drive (automatic transmission) or Neutral (manual transmission).

4.3.1.1.4 Fifteen (15) Minute Break. Shut off engine. If only the city traffic procedure is required, the test may be terminated at this point. If the global sequence test is required, perform a 15 minute engine off soak. For on-road facilities, arrangements should be made to attach the towing dynamometer during this soak period. It is acceptable to drive to the Dynamometer (DYNO) or 90 km/h grade load (GL) location before shutting off the vehicle. Proceed with the 50 km/h, 7.2% GVMR condition. The grade load should be started no later than 25 minutes after the end of the 20 minute idle after city traffic.

4.3.1.2 Part 2 (50 km/h 7.2% GVMR + Soak). Start the vehicle. If necessary, drive to the test location. The total time to reach the test location shall not exceed five minutes. Accelerate to 50 km/h. Drive 50 km/h until temperatures stabilize. Set load to 50 km/h, 7.2% GVMR. Run 50 km/h 7.2% for 25 km. At designated vehicle soak location, decelerate to 0 km/h. Shut off the engine. Soak the vehicle for 30 minutes.

4.3.1.3 Part 3 (High Speed). Start the engine. If necessary proceed to the high speed test location. The total time to reach high speed test location shall not exceed five minutes. Accelerate the vehicle to 155 km/h. Maintain speed for 50 km. At the end of 50 km proceed to an appropriate idle location. Decelerate the vehicle to 0 km/h.

4.3.1.4 Idle 30 Minutes. While the vehicle is in Drive (automatic transmission) or Neutral (manual transmission), idle the vehicle for 30 minutes. Shut off the engine. Test complete.

4.3.2 Minimum Speed Ratio (MSR). The following applies to applications with discrete, multi-speed, automatic transmissions. The appropriate test points are to be provided by the GM Powertrain transmission calibrator working with the GM Powertrain Transmission Development Group. It is expected that GM Powertrain will supply targeted vehicle speed, gear transition (e.g., 2nd to 3rd), and pedal position percentage of gear shift. For development purposes, minimum speed ratio points can be determined using the procedure in Appendix C.

4.3.2.1 Condition 2.1 - MSR Test Template, High Ambient.

4.3.2.1.1 The testing should be repeated for each required test point.

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January 2016

Page 15 of 58



Documents

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4.3.2.1.2 Stabilize tunnel to the environmental conditions listed in Table 1. Solar load is optional.

4.3.2.1.3 Accelerate the vehicle to the vehicle speed provided. With the dynamometer in speed mode, increase the throttle percentage to 5% below required pedal position as provided by GM Powertrain. **Note:** Transmission sump temperature rise is to be controlled through the modulation of dynamometer load and accelerator pedal position. The pedal position should be increased gradually so as to avoid entry into transmission predictive hot mode. The dynamometer load should be monitored. If the load exceeds 7.2% GCMR, reduce the pedal position until 7.2% GCMR is not exceeded and run the test at 7.2% GCMR

4.3.2.1.4 At a transmission sump temperature of 95 °C: Increase the pedal position to 3% below the target point provided by GM Powertrain, again, being sure not to exceed the 7.2% GCMR dynamometer load limit.

4.3.2.1.5 At a transmission sump temperature of 100 °C: Zero the odometer and continue running test point for 16 km. At the completion of 16 km the test point is complete.

Note: If the vehicle reaches powertrain fluid limit temperatures, prior to reaching transmission temperature limits, then end test prior to completion of 16 km. Transmission temperatures at end point of test are used for evaluation.

Note: Engine power may degrade during the 16 km distance and result in an undesired transmission shift if the accelerator pedal is further depressed to maintain a fixed load. Run the test point with the accelerator pedal fixed at 3% from the shift and allow the dynamometer load to vary, maintaining the MSR condition.

4.3.2.1.6 Cool vehicle so that engine and transmission sump temperatures are at or below 90 °C and radiator is at or below thermostat control point. Repeat for each required test point.

Note: A downshift of a transmission during a test run due to the entrance of a transmission Hot Mode may be regulated in the program Powertrain Cooling VTS.

4.3.2.2 Condition 2.2 - MSR Test Template, Moderate Ambient. Stabilize tunnel temperature to 15 °C and 30% humidity. Turn the A/C system OFF for this condition. Repeat steps 4.3.2.1.3 through 4.3.2.1.6.

4.3.3 Condition 3 and 3.1– Ninety (90) km/h 7.2% GVMR + Soak. At the environmental conditions specified in Table 1, precondition the vehicle at 90 km/h GVMR road load until conditions stabilize. Run vehicle at 90 km/h, 7.2% GVMR for 25 km. At end of hill, decelerate the vehicle until stopped. Shut off the engine and soak the vehicle for 20 minutes. Test complete.

4.3.3.1 Condition 3.2 – Ninety (90) km/h 7.2% GVMR + Soak – Jabel Hafeet. At the environmental conditions specified in Table 1, precondition the vehicle at 90 km/h, GVMR road load until conditions stabilize. Once conditions stabilize, initiate the Jabel Hafeet hill simulation shown in Appendix B, Table B4. At end of hill, decelerate the vehicle until stopped. Shut off the engine and soak the vehicle for 20 minutes. Test complete.

4.3.4 Regional Conditions – GMNA.

4.3.4.1 Condition 4 – Ninety (90) km/h Davis Dam GCMR + Soak. At the environmental conditions specified in Table 1, precondition the vehicle at 90 km/h GCMR road load until conditions stabilize. Once conditions stabilize, initiate the Davis Dam hill simulation. At end of hill, decelerate the vehicle until stopped. Shut off the engine and soak the vehicle for 20 minutes. At the end of the 20 minute soak, restart the vehicle. Accelerate at WOT in drive to 90 km/h. Test complete. Once conditions stabilize, initiate the Davis Dam hill simulation per Davis Dam Hill profile in Appendix B, Table B1.

4.3.4.2 Condition 5 – Ninety (90) km/h Stovepipe GCMR + Idle. At the environmental conditions specified in Table 1, precondition the vehicle at 90 km/h GCMR road load until conditions stabilize. Once conditions stabilize, initiate the Stovepipe simulation using the hill profile in Appendix B, Table B2. At end of hill, decelerate the vehicle until stopped. Idle the vehicle for 15 minutes (in Drive for automatic transmissions or Neutral for manual transmission). Test complete.

4.3.4.3 Condition 6 - (Single Grounded Spark Plug Tests). Perform a visual inspection of the vehicle before and after completing each test. Converter temperatures should be monitored during this procedure.

4.3.4.3.1 Preparation. Disable the firing circuit to the spark plug of the cylinder closest to the oxygen sensor. The recommended method for doing this is to pull the B+ power pin from the coil to disable the coil. A jumper harness with the B+ pin disabled can be inserted between the coil harness and the engine harness to disable the spark plug. This often avoids a diagnostic trouble code being set. An alternate method is to provide a grounded path such as a welded spark plug grounded to the chassis. This method can be made to work, but often has unintended grounding issues. If the vehicle contains a misfire detection algorithm, it must be disabled.

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January 2016

Page 16 of 58



Documents

Document Sharing Hub

The method for disabling the misfire detection algorithm is left to the test personnel but usually involves obtaining a calibration from the Engine Calibrator.

4.3.4.3.2 Multiple Converter Systems. If the vehicle has multiple exhaust/converter systems, repeat the required conditions for all bank/converter combinations.

4.3.4.3.3 Failed Plug Test Procedure. Prepare the vehicle per 4.3.4.3.1. At the environmental conditions specified in Table 1, precondition the vehicle at 50 km/h GVMR road load until conditions stabilize. Run the vehicle at 50 km/h, 7.2% GVMR for 25 km. At end of hill, decelerate the vehicle until stopped. Shut off the engine and soak the vehicle for 20 minutes. Test complete.

4.3.5 Regional Conditions – Europe.

4.3.5.1 Condition 7 (GCMR, 12%, Idle 2 Minute, Soak). At the environmental conditions specified in Table 1, set the A/C to off and precondition vehicle at 80 km/h GVMR until stabilized conditions are achieved. Set the vehicle load to 12% GCMR. Select the appropriate gear per 4.2.7. Adjust the vehicle speed to 55 km/h and run at the engine rpm for 55 km/h. If the engine power is not sufficient to maintain 55 km/h, downshift one gear. If necessary reduce the vehicle speed to keep the engine rpm below the point of maximum engine power. Run this condition for 12 km. At end of 12 km, decelerate vehicle until stopped. Idle the vehicle for two minutes (in Drive for automatic transmissions and Neutral for manual transmissions.) Shut off engine (tunnel temperature drop up to 5 °C is permissible during soak). Test is complete when engine coolant temperature and pressure drop continuously for five minutes.

(The entire test is run at constant vehicle speed such that maximum engine rpm is not exceeding the rpm of maximum engine power.)

4.3.5.1.1 Condition 7.1 – Non-Trailer Vehicle CAC Sizing (GVMR, 16%, Idle 2 Minute, Soak). At the environmental conditions specified in Table 1, set the A/C to off and precondition vehicle at 80 km/h GVMR until stabilized conditions are achieved. Set the vehicle load to 16% GVMR. Select the appropriate gear per 4.2.7. Adjust the vehicle speed to 55 km/h and run at the engine rpm for 55 km/h. If the engine power is not sufficient to maintain 55 km/h, downshift one gear. If necessary reduce the vehicle speed to keep the engine rpm below the point of maximum engine power. Run this condition for 12 km. At end of 12 km, decelerate vehicle until stopped. Idle the vehicle for two minutes (in Drive for automatic transmissions and Neutral for manual transmissions.) Shut off engine (tunnel temperature drop up to 5 °C is permissible during soak). Test is complete when engine coolant temperature and pressure drop continuously for five minutes. If it is necessary to abort the test due to high Powertrain Cooling (PTC) vital temperatures, the charge air cooler duct outlet temperature at the time of the abort should be used to compare the requirement.

(The entire test is run at constant vehicle speed such that maximum engine rpm is not exceeding the rpm of maximum engine power.)

4.3.5.2 Condition 8 (GVMR, 12%, Soak). At the environmental conditions specified in Table 1, precondition vehicle at 80 km/h GVMR until stabilized conditions are achieved. Set the vehicle load to 12% GVMR. Select the appropriate gear per 4.2.7. Adjust the vehicle speed to 70 km/h. If the engine rpm is greater than that engine rpm at the maximum power point, reduce the vehicle speed until the engine rpm is at the maximum power point. If the engine power is not sufficient to maintain 70 km/h, downshift one gear. If necessary reduce the vehicle speed to keep the engine rpm below the point of maximum engine power. Run this condition for 12 km. At end of 12 km, decelerate vehicle until stopped. Shut off engine (tunnel temperature drop up to 5 °C is permissible during soak) and soak the vehicle for 20 minutes. Test complete.

(The entire test is run at constant vehicle speed such that maximum engine rpm is not exceeding the rpm of maximum engine power.)

4.3.5.3 Condition 9 (Trailer Grade Load (TGL) 6%, 13 km). At the environmental conditions specified in Table 1, precondition the vehicle at 80 km/h GCMR road load until conditions stabilize. Run vehicle at 80 km/h, 6% GCMR for 13 km. At end of hill, decelerate the vehicle until stopped. Idle the vehicle for 15 minutes (in Drive for automatic transmissions or Neutral for manual transmission). Test complete.

4.3.5.4 Condition 10 and 10.1 (Road Load (RL), Maximum Speed). At the environmental conditions specified in Table 1, accelerate the vehicle to 200 km/h road load. If the vehicle cannot achieve 200 km/h, run the vehicle at maximum speed (WOT). Maintain 200 km/h (or WOT) for 50 km, decelerate the vehicle to a stop. Shut off the engine and soak for 20 minutes. If the maximum vehicle speed is > 200 km/h, restart the vehicle and accelerate to maximum speed (WOT) at GVMR. Run at maximum speed for 50 km (if 200 km/h < maximum speed

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< 225 km/h) or 37.5 km (if maximum speed $\geq$ 225 km/h). Decelerate the vehicle to 0 km/h. Idle the vehicle (in Park for an automatic transmission or Neutral for a manual transmission) for 30 minutes. Test complete.

4.3.5.4.1 Condition 10.2 (Road Load (RL), Maximum Speed – Middle East). At the environmental conditions specified in Table 1, accelerate the vehicle to 200 km/h road load. If the vehicle cannot achieve 200 km/h, run the vehicle at maximum speed (WOT). Maintain 200 km/h (or WOT) for 50 km, decelerate the vehicle to 0 km/h. If the maximum vehicle speed is $\leq$ 200 km/h, idle the vehicle (in Park for an automatic transmission or Neutral for a manual transmission) for 30 minutes. Test complete. If the maximum vehicle speed is > 200 km/h, shut off the engine and soak for 20 minutes. Restart the vehicle and accelerate to maximum speed (WOT) at GVMR. Run at maximum speed for 50 km. Decelerate the vehicle to 0 km/h. Idle the vehicle (in Park for an automatic transmission or Neutral for a manual transmission) for 30 minutes. Test complete.

4.3.5.4.2 Condition 10.3 (Road Load (RL), Maximum Speed – Global Durability). At the environmental conditions specified in Table 1, run the Durability Event: High Speed Vmax per GMW17168. If the condition is run on road, follow the facility specific driving instructions.

4.3.5.4.3 Condition 10.4 (Road Load (RL), Maximum Speed – CAC Sizing). Set the environmental conditions to the values specified in Table 1.

The intention of this condition is to have the engine operating at, or near, maximum engine power. When pushing the accelerator pedal to 100%, if the calibration of the vehicle causes non-intended operating points (e.g., power reduction, unintended transmission gear choices), it is acceptable to reduce the pedal position to cause gear shifts or to manually select specific gears to achieve the intended operating condition. The air temperature at the CAC duct outlet (engine inlet) should be monitored. This temperature should be monitored for at least 10 km once the operating point is achieved. The CAC duct outlet temperature is considered stabilized when it does not vary more than 1 °C for 1 minute when driven at least 10 km.

It will be necessary to monitor PTC vital temperatures, if PTC vital temperatures reach the abort criteria, note the CAC duct outlet temperature prior to aborting. If CAC duct outlet temperatures exceed 80 °C gas or 100 °C diesel, abort the test. Finally, it is important with all high speed testing to be sure the vehicle tire rating is consistent with vehicle test speeds. The tires should be properly inflated and monitored during testing.

a. Procedure where maximum vehicle speed is not limited by calibration or facility dynamometer

Accelerate the vehicle to the maximum vehicle speed. Use the Wind Speed Adjustment procedure to set the wind speed (4.3.5.4.3.c) if necessary. Run the vehicle at WOT at the intended maximum vehicle speed until the CAC duct outlet temperature stabilizes. Once the temperature stabilizes, decelerate the vehicle to 0 km/h. Idle the vehicle in Park if automatic transmission or neutral if manual transmission for 10 minutes. Shut off the vehicle. Test complete.

b. Procedure where the vehicle speed is limited by calibration or facility dynamometer capability

If the theoretical vehicle maximum speed is more than 40 km/h greater than the achieved maximum vehicle speed, this procedure may not be valid and other methods should be considered for sizing the charge air cooler (e.g., performance vehicles with race track conditions).

Accelerate the vehicle to the maximum achievable vehicle speed. Set the tunnel wind speed to the maximum theoretical vehicle speed. If this is not achievable, use the wind speed adjustment procedure (4.3.5.4.3.c). At the maximum achieved vehicle speed, run the vehicle at maximum engine power by using percent grade or similar method to increase load. The transmission gear should be selected to achieve an engine rpm closest to, but not higher than, the engine speed at the theoretical maximum vehicle speed. Run until the CAC duct outlet temperature stabilizes. Once the temperature stabilizes, decelerate the vehicle to 0 km/h. Idle the vehicle in Park if automatic transmission or neutral if manual transmission for 10 minutes. Shut off the vehicle. Test complete.

c. Wind Speed Adjustment Procedure – For use when tunnel wind speed cannot achieve vehicle theoretical maximum speed

This procedure relies on extrapolation. If the vehicle theoretical maximum speed is more than 40 km/h greater than the achievable facility wind speed, this procedure may not be valid.

If the wind tunnel air speed cannot achieve the theoretical maximum vehicle speed, the wind speed should be set at the maximum achievable facility wind speed. Once the CAC duct outlet temperature stabilizes, note the temperature and reduce the air speed by 20 km/h. Let the CAC duct outlet temperature stabilize and note the temperature. Reduce the wind speed an additional 20 km/h (total 40 km/h). Let the CAC duct outlet temperature

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January 2016

Page 18 of 58



Documents

Document Sharing Hub