



## Heater Objective and Subjective Performance Validation for Passenger Vehicles at Suburban Traffic Conditions

### 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 standard is the validation of the performance capability of a vehicle heating system by reproducible measurements in a climatic wind tunnel for suburban traffic conditions.

**1.2 Applicability.** This standard applies to all passenger vehicles with a heater system.

**1.3 Remarks.** Not applicable.

### 2 References

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

#### 2.1 External Standards/Specifications.

None

#### 2.2 GM Standards/Specifications.

GMW3058              GMW15845

#### 2.3 Additional References.

- Vehicle Technical Specification (VTS).

### 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.

**3.1.3** Climatic wind tunnel including an adjustable chassis dynamometer.

**3.1.4** Capability for a vehicle speed of 110 km/h minimum, a wind speed of 110 km/h minimum, and an ambient temperature of -35 °C minimum.

#### 3.2 Equipment.

**3.2.1** Data measuring and recording equipment capable of measuring data described in Appendix A, Tables A1, A2, A3, and A4.

**3.2.2** Device for operation and adjustment of accelerator pedal.

**3.2.3** Battery Charger to maintain battery during cold soak (see 4.2.2.2).

**3.3 Test Vehicle/Test Piece.** Passenger vehicles equipped with a heater system.

**3.4 Test Time.**

Calendar time: 2.0 days

Test hours: 4 h

Coordination hours: 8.0 h

**3.5 Test Required Information.** Test conditions as specified by the Vehicle Technical Specification (VTS).

**3.6 Personnel/Skills.** One climatic tunnel operator and one driver, if necessary.

**4 Procedure**

**4.1 Preparation.** The vehicle shall be equipped with all equipment described in 3.2 prior to being installed in the climatic wind tunnel. Instrumentation installed per GMW15845. Instrumentation channels required to be monitored during this test are defined in Appendix A, Tables A1, A2, A3, and A4.

**4.1.1 Engine Oil, Coolant and Fuel.** As released for the engine at the test temperature.

**4.1.2 Tire Pressure.** Tires to be inflated to the maximum rated pressure.

**4.1.3 Battery State of Charge.** The vehicle's low voltage battery should be of good health with state of charge > 60% prior to start of test. For applicable vehicles with a propulsion or propulsion assist battery, the maximum state of charge should be achieved prior to start of test.

**4.1.4 Heating, Ventilation and Air Conditioning (HVAC) Settings.** The vehicle ventilation system controls shall be set to full hot, floor mode, and Outside Air Mode (OSA). The blower(s) setting is specified in 4.3.2. Outboard panel outlets to remain in open position with airflow aimed parallel to respective side glass at the height of the occupant shoulder. Inboard panel outlets to remain open and aimed respectively to driver and passenger shoulder area.

**Note:** It is permissible to run test with air inlet in a partial recirculation condition, provided this logic is automatically controlled. Uncontrolled test chamber humidity should be monitored as it may have an impact on the function of partial recirculation.

**4.2 Conditions.**

**4.2.1 Environmental Conditions.** Standard conditions are as follows.

- Test Temperature:  $(-20 \pm 1)^\circ\text{C}$ .
- Accelerated soak:  $5^\circ\text{C}$  below test temperature. See 4.2.2.2.1 for detailed instructions.

**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 Vehicle and Wind Speeds.** Vehicle and wind speeds as specified in the measurement programs (see 4.3) (wind speed for pre-soak may be modified to accelerate test).

**4.2.2.2 Soak.** It shall be ensured that the entire vehicle is at a uniform temperature which is in the range of  $\pm 1^\circ\text{C}$  of the test temperature prior to start of test. Temperatures of the vehicle's coolant, engine oil, and transmission oil should be monitored during the soak. A battery charger is to be applied to the vehicle's low voltage battery during the soak condition.

**4.2.2.2.1 Accelerated Soak** has a cycle time of (2 to 3) h, with procedure as follows. Open all passenger doors. Sand bags should be applied to door hinge area to keep door open through the duration of the soak. Set chamber temperature to  $-25^\circ\text{C}$  and wind speed to 80 km/h. Once engine oil sump temperature reaches  $-21.5^\circ\text{C}$  bring the tunnel temperature back to  $-21^\circ\text{C}$  and lower wind speed to 15 km/h. Engine oil temperature will rebound to  $-20^\circ\text{C}$ . Once this occurs, bring tunnel temperature back to  $-20^\circ\text{C}$ . Monitor coolant, engine oil, and transmission oil temperatures. When all three are within  $\pm 1^\circ\text{C}$  of test temperature, the schedule should be started.

**4.2.2.3 Warmup Conditions.** Vehicle and wind speeds as specified in the measurement program (see 4.3).

**4.2.2.4 Idle Conditions.** Wind speed as required to maintain tunnel test temperature (10 km/h maximum).

**4.2.2.5. Vehicle Weight.** Test conducted with vehicle at curb weight with a full tank of gas and one passenger (68 kg).

**4.2.2.6 Electrical Power Supply.** All electrical systems are supplied by the internal vehicle power supply. Headlights (low beam), backlight defogging system and heated seats on high setting (if standard equipment) are switched on at:  $t = 0$  minutes.

**4.2.2.7 Gear Steps or Drive Positions.** 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. 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.

**4.2.2.7.1** For repeat measurements on vehicles with automatic transmissions, it shall be ensured that same vehicle speeds are driven at the same lowest engine speeds.

**4.2.2.7.2** For manual transmissions, gears shall be changed as follows.

- Shifts at  $(3000 \pm 200) \text{ min}^{-1}$  ( $3000 \pm 200 \text{ rpm}$ ).

#### 4.3 Instructions.

**4.3.1 Measuring Values and Data to Record.** All data (See Appendix A, Tables A1, A2, A3, and A4) shall be recorded at 1 s intervals.

##### 4.3.1.1 Further Data.

- Vehicle data, mileage and description of the system to be validated.
- Test number and date.
- Name of the person in charge of the test.
- List of calibrated test equipment.

**4.3.2 Heater Test - Suburban Traffic - Cycle 1 Objective Evaluation.** See Appendix B, Figure B1.

**4.3.2.1** Cool down the vehicle until coolant, engine oil, and transmission oil have reached the temperatures as described in 4.2.2.2.

**4.3.2.2** After the soak is complete, the driver enters the vehicle. With vehicle in accessory power mode, set HVAC mode to floor, temperature to full hot and adjust the blower setting to match airflow quantity which is aligned to vehicle segment and defined per Table 1. After mode and blower are set, the driver starts the engine. This is:  $t = 0$  minutes.

**Note:** Airflow quantity measured per GMW3058 in floor mode full hot. Reference vehicle system engineer for vehicle segment selection.

**Table 1: HVAC Blower Setting**

|                                            | Vehicle Segment |    |    |           |    |
|--------------------------------------------|-----------------|----|----|-----------|----|
|                                            | A               | B  | C  | D (w/aux) |    |
| <b>Airflow (L/s)</b> <small>Note 1</small> | 60              | 65 | 75 | 75        | 35 |

**Note 1:** Airflow tolerance of  $\pm 2 \text{ L/s}$ .  
**w/aux** With auxiliary  
**LPS** Liter per second

**4.3.2.3** Headlights (low beam), backlight defogging system and heated seats (if standard equipment) are switched on at time,  $t = 0$  minimum.

**4.3.2.6** At time  $t = 0$  minutes, the tunnel operator records a full set of data; then start the Suburban Traffic schedule by idling for 90 s. At ( $t = 1$  minute 30 s), accelerate to 25 km/h, over a period of 5 s, and maintain speed for 45 s ( $t = 2$  minutes 20 s) then decelerate to a stop lasting only for 1 s, then accelerate to 40 km/h, over a period of 5 s, and maintain for 90 s. At this time ( $t = 4$  minutes.), decelerate to a stop and idle for 65 s followed by an acceleration to 50 km/h, over a period of 7 s, and maintain for 120 s. At this time ( $t = 7$  minute 15 s), decelerate to a stop and idle for 60 s and then accelerate to 70 km/h, over a period of 10 s, and maintained for 100 s. At this time ( $t = 10$  minute 10 s) decelerate to a stop for 60 s followed by an acceleration to 40 km/h, over a period of 5 s, and maintain for 8 minutes 38 s. This concludes the Suburban Traffic schedule ( $t = 20$  minutes).

**4.3.2.7** At the completion of the Suburban Traffic schedule ( $t = 20$  minutes), accelerate from 40 km/h to 100 km/h over a period of 5 s. At time ( $t = 40$  minutes) the highway schedule is complete.

**4.3.2.8** At time ( $t = 40$  minutes), decelerate to an idle condition for a period of 10 minutes with transmission in drive.

**4.3.2.9 End of Test.** The test concludes at the end of the 10 minute idle or time,  $t = 50$  minutes.

**4.3.3 Heater Test - Suburban Traffic – Cycle 2 Subjective evaluation.** Reference Appendix B, Figure B1 and Appendix C.

**4.3.3.1** Soak the vehicle as described in 4.2.2.2. Individuals who are to ride in the vehicle will pre-condition themselves for 10 minutes in the control room area followed by standing inside the climatic tunnel for 5 minutes. This is to ensure all riders acclimate to ambient conditions prior to entering the vehicle.

**Note:** Appropriate clothing for a temperature of  $-20^{\circ}\text{C}$  should be worn. Over-shoes or insulated boots are not to be worn. The intent is not to enter the vehicle until all personnel soak to a uniform subjective comfort level of "1" (cold). More detail on the comfort scale can be seen in Appendix C.

**4.3.3.1.1** After the pre-conditioning period, the test personnel will enter the vehicle. Close the rear doors. Leave the front doors open to prevent windshield fogging/frosting. Driver and all passengers must wear seat belts for the duration of the test.

**4.3.3.2** With vehicle in accessory power mode, set HVAC mode to floor, temperature to full hot and adjust the blower setting to match airflow quantity which is aligned to vehicle segment and defined per Table 1. After mode and blower are set, ensure all doors are closed and the driver starts the engine. This is:  $t = 0$  minutes.

**4.3.3.2.1** If the vehicle is equipped with a rear HVAC system, set the temperature control to full hot position (if applicable) and blower speed as defined in Table 1.

**4.3.3.3** Record initial subjective  $t = 0$  comfort readings on the data sheet (See Appendix C for comfort rating scale). The front passenger records the driver's comfort rating after recording his/her own comfort rating.

**Note:** The driver should not communicate his/her comfort rating verbally. Since comfort ratings are subjective opinions of the individuals evaluating the vehicle, care should be taken to not discuss ratings during the test as this may influence the opinions of the other riders. The driver can indicate his/her comfort rating by pointing to numbers from 1 through 9 marked on the back of the front passenger's clipboard.

**4.3.3.4** Once the vehicle is started and running, start the Suburban Traffic schedule portion of the drive cycle as outlined in section 4.3.2 and Appendix B, Figure B1. Driver to operate automatic and manual transmissions as described in 4.2.2.7.

**Note:** After 10 minutes, the front passengers control their comfort level by modulating the temperature, blower speed and outlet direction. HVAC mode to remain in floor setting. If the vehicle is equipped with a rear HVAC system, the rear passengers may change outlet direction as well as temperature and blower speed settings. Record the temperature, blower speed, and outlet direction changes on the data sheet. For manual systems, record temperature control position changes as a percent of total control travel. For automatic systems, record actual temperature setting.

**4.3.3.5** Record subjective comfort readings on the data sheet at 4 minutes, 8 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 45 minutes, and 50 minutes.

**4.3.3.6 End of Test.** The test concludes at the end of the 10 minute idle or time,  $t = 50$  minutes.

## 5 Data

**5.1 Calculations.** Not applicable.

**5.2 Interpretation of Results.** The targets are defined by the VTS.

**5.3 Test Documentation.** With reference to this test procedure, the results of the measurements shall be presented in a test report.

## 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.

**Acceleration and Deceleration:** Unless otherwise specified, the acceleration and deceleration rates should be within 4 km/h/s and 6 km/h/s. These values do not apply to the city/suburban traffic portion of the test.

**Air Outlet Vents:** "Air Outlet Vents" is the average of the air outlet temperatures at the vent nozzles. The temperature sensors shall be installed in the center of the outlets in such a way that they extend 10 mm minimum into the outlets and do not touch any parts of the air ducting system.

**Breath Level:** The "breath level" for a particular row is the average of the temperatures recorded by the breath level temperature sensors of that row. The temperature sensor(s) for each seat position shall be installed according to GMW15845.

**Footwell:** Footwell is the average of 5 temperatures in each front and 3 temperatures in each rear footwell area. Notes for the floor temps: The temperature measurement points are located in the footwells within a square (300 mm x 300 mm) in front of each seating position at a height of 30 mm above the floor. The fore-aft location of the grid center is at the occupant heel point and the cross car location of the grid center is at the occupant centerline. See Appendix D, Figure D1 and Appendix E, Figure E1.

**Idle:** Idle operation after the warmup phase as specified by the test program.

**Test Temperature:** The climatic tunnel ambient as defined per the VTS for the specific test condition.

### 7.2 Acronyms, Abbreviations, and Symbols.

|       |                                           |
|-------|-------------------------------------------|
| #     | Number                                    |
| APC   | Air Per Cycle                             |
| AT    | Automatic Transmission                    |
| BRV   | Block Rotary Valve                        |
| CAN   | A file format for storing information     |
| DPF   | Diesel Particulate Filter                 |
| DT    | Dwell Time                                |
| ECAM  | Exhaust Cam                               |
| ECU   | Electronic Control Unit                   |
| EGR   | Exhaust Gas Recirculation                 |
| ET    | Energized Time                            |
| HP    | High Pressure                             |
| HVAC  | Heating, Ventilation and Air Conditioning |
| ICAM  | Intake Cam                                |
| LP    | Low Pressure                              |
| MAP   | Manifold Absolute Pressure                |
| Min   | Minute                                    |
| MRV   | Main Rotary Valve                         |
| OSA   | Outside Air Mode                          |
| PTC   | Positive Temperature Coefficient          |
| RPM   | Revolutions per Minute                    |
| SOI   | Start of Injection                        |
| Temp. | Temperature                               |
| TVA   | Throttle Valve Actuator                   |
| VTS   | Vehicle Technical Specification           |

## 8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW8697