



Defroster System Maximum Performance Validation 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. Validation of the performance capability of a vehicle windshield and side window defrosting system using reproducible measurements in a climatic wind tunnel.

1.2 Applicability. For all passenger vehicle defroster systems.

1.3 Remarks. Relative humidity of the climatic wind tunnel is a significant factor in determining the defrosting performance of the vehicle per this procedure. It is imperative that the recommendation for relative humidity outlined in this procedure be followed for consistent deicing performance.

2 References

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

2.1 External Standards/Specifications.

FMVSS 103 FMVSS 104 SAE J902

2.2 GM Standards/Specifications.

GMW15845

2.3 Additional References.

- Vehicle Technical Specifications (VTS)

3 Resources

3.1 Facilities. Climatic wind tunnel including a chassis dynamometer capable of controlling a dynamometer speed of 50 km/h minimum, wind speed of 50 km/h minimum, and an ambient temperature of -30 °C minimum with relative humidity (RH) control between 10% and 95% RH.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Temperature measuring and recording equipment for at least 14 measurements per 4.3.2 and GMW15845.

3.2.2 Measuring and recording equipment for voltage and current for compartment blower(s), battery(s) (voltage only) per 4.3.2.

3.2.3 Measuring and recording equipment for the engine speed per 4.3.2.

3.2.4 Engine Oil/Coolant. As released for the engine at the test temperature.

3.2.5 Device for operation and adjustment of accelerator pedal.

3.2.6 Spray gun for applying water to windshield (Binks Model 62 spray gun, with fluid nozzle 66 and air nozzle 66SD, 66SF, or equivalent equipment as specified in SAE J902).

3.2.7 Scale for measuring quantity of water required to fill into the spray gun. Weight method preferred over fluid scale.

3.2.8 Distilled water held at a refrigerated temperature of $(2 \pm 1) ^\circ\text{C}$

3.2.9 Timing device with stopwatch functions.

3.2.10 Means of recording cleared glass area for all tests (felt tip marker, etc.)

3.2.11 Degrease window (s) using Klean Strip (a denatured alcohol).

3.2.12 Clean the window(s) using Windex Original (a glass cleaner).

3.2.13 Camera.

3.2.14 Optional: Auxiliary power source to power the vehicle blower motor and prevent frost build-up on the brushes and commutator of blower motor during pre-soak.

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

3.3.1 Test Vehicle Calibration. Prior to conducting this test procedure, ensure that the test vehicle has been successfully flashed with the latest engine and transmission calibration available in CRETA.

3.3.2 Reported Diagnostic Trouble Codes (DTC). It is imperative that any Diagnostic Trouble Codes (DTC) reported during test be interrogated for their potential impact on the result of this test. Contact the appropriate engine and/or transmission calibration lead to understand which DTC's need to be resolved to ensure a valid test.

3.4 Test Time.

Calendar time: 1 d

Test time: 4 h

Coordination time: 8 h

3.5 Test Required Information. Area of windshield and one front side window is used to calculate amount of water to fill into the Spray Gun. The vision areas of the windscreen are described in Appendix B.

3.6 Personnel/Skills. One climatic tunnel operator, one driver and one observer.

4 Procedure

4.1 Preparation. The vehicle shall be prepared for the climatic tunnel using equipment and procedures according to 3.2 and 4.3.2.

4.1.1 Engine Oil. Coolant and Fuel. Ensure that test vehicle contains fluids as released that are appropriate for the test ambient temperature. Winter grade fuel or other fluids may impact the ability for proper engine ignition.

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

4.1.3 Battery State of Charge. The vehicles 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. Battery electric vehicles to remain plugged into Level 2 charger through the pre-soak, spray and soak sections of this test.

4.1.4 Cleaning of the Windows. The inner surfaces of all vehicle glass (including backlight) shall be completely degreased with Klean Strip (a denatured alcohol). After degreasing agent is completely dry, clean the glass with Windex Original (a glass cleaner). The surface treated in this manner shall be allowed to dry and then wiped with a dry cotton cloth.

4.1.5 Heating, Ventilation and Air Conditioning (HVAC) Settings. The vehicle front ventilation system controls shall be set to Full Hot, Defrost, Outside Air (OSA) and high blower speed. If equipped with an auxiliary blower or rear HVAC blower, these are to remain off throughout the duration of this test.

4.1.5.1 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.

4.1.6 Functional Operation of the System. Verify the functional operation of HVAC temperature, mode and blower controls prior to pre-soak.

4.2 Conditions.

4.2.1 Environmental Conditions. Pre-soak temperature can be modified to accelerate test.

Standard condition:

- Test temperature: $-4\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$
- Test humidity: $90\% \pm 5\%$
- Pre-soak: $-9\text{ }^{\circ}\text{C}$ test temperature, $80\% \text{ RH} \pm 10\% \text{ RH}$

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.

Deviations from the requirements of this standard shall have been agreed upon with the program thermal lead development engineer and windshield clearing vehicle performance owner.

4.2.2.1 Vehicle and Wind Speeds. Vehicle and wind speeds as specified in Table 1 (see 4.3.1). Wind speed for pre-soak can be modified to accelerate test.

4.2.2.2 Electrical Power Supply. All electrical systems are supplied by the internal vehicle power supply.

Note: Heating Ventilation and Air Conditioning (HVAC) blower motor can be operated during soak with an auxiliary power source to prevent frost build-up on motor brushes and commutator.

4.2.2.3 Spray and Soak. See test overview in Table 1. The engine oil temperature and windshield glass surface temperature shall be equal to the test temperature ($\pm 1\text{ }^{\circ}\text{C}$) prior to Spray and Soak. Reference Appendix D, Figure D1 for instructions on location of windshield surface temperature location. The water in the spray gun should be held at a constant temperature of $(2 \pm 1)\text{ }^{\circ}\text{C}$ prior to spraying the glass. Water shall be applied to glazed surfaces according to 4.3.3. Water quantity 0.18 g per cm^2 of glazed surface. Water quantity should be determined, using weight scale, prior to pre-soak (Table 1), then kept in a refrigerator with spray gun tank. The frost shall cure for 30 minutes.

4.2.2.4 Test. Headlights (low beam), electrical heated windshield, backlight defogging system and heated seats (if standard equipment) are switched on to maximum performance. Windshield wipers may be operated for certain vehicles as defined by the VTS (default configuration is wipers off).

4.2.2.5 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.

4.2.2.5.1 The specified dynamometer speeds are driven at coastdown road load (on level stretches without acceleration).

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

4.2.2.5.3 For manual transmissions, gears shall be changed as follows.

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

4.2.2.6 Dynamometer Loading. Dynamometer loading to be set to coastdown road load at a vehicle mass of curb weight plus driver.

4.2.2.7 Coastdown Road Load Coefficients. Coastdown road load coefficients provided by the program energy lead should be used whenever possible to generate the most accurate dynamometer load. The lowest coastdown road load values should be selected for the given test vehicle build configuration, therefore validating the worst case performance condition. When testing a benchmark vehicle reference the following website, <https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy>, for a potential match of coastdown road load data. Dynamometer load based on drag should only be applied when coastdown road load data is not available.

4.3 Instructions.

4.3.1 Climatic Tunnel Schedule. See Table 1.

Table 1: Climatic Tunnel Schedule

	Ambient	HVAC Mode	Dynamometer Speed	Wind Speed	Duration
1 Pre-soak	-9 °C at 80% RH	Not applicable	0 km/h	30 km/h	Until engine and transmission oil reaches -4 °C
2 Spray	-4 °C at 90% RH	Not applicable	0 km/h	10 km/h	Spraying of windows
3 Soak	-4 °C at 90% RH	Not applicable	0 km/h	15 km/h	30 minutes
4 Test	-4 °C at 90% RH	Full Hot, Defroster, high fan	50 km/h	50 km/h ^{Note 1}	40 minutes from time of engine start

Note 1: See 4.3.3.5.

4.3.2 Measuring Values and Data to Record. All instrumentation (See Appendix C, Table C1, Table C2, Table C3, and Table C4) shall be installed per GMW15845 and recorded at 1 s intervals.

4.3.2.1 Further Data.

- Vehicle Data, Mileage, Engine/Transmission calibration and Description of the System to Validate
- Test Number and Date
- Name of the Observer(s) and the Person in Charge of the Test
- List of Calibrated Test Equipment

4.3.3 Test Description.

4.3.3.1 See test overview in Table 1. Pre-soak the vehicle with hood and doors or windows open at -9 °C by 80% RH with a wind speed of 80 km/h. Take a photo of the primary windshield defroster outlet grill from outside the vehicle using a centerline windshield location and filling the viewfinder with the complete grill while insuring the camera focus of the grill vanes. **Note:** This camera view location and focus will be used in photos later in the test.

4.3.3.2 Once engine and transmission oil temperatures reach (1 to 2) °C below the test temperature, the tunnel temperature shall be raised to test temperature and the hood shall be closed. If windows are open, close prior to spraying glazed surfaces. Monitor windshield surface temperature, once this temperature is (-4 ± 1) °C, the windshield spray procedure may commence.

4.3.3.3 Glass spray procedure. The tunnel wind speed is reduced to 10 km/h. Ensure that distilled water at a temperature of (2 ± 1) °C is available to complete this procedure. The windshield and side windows shall be sprayed with 0.18 cm³ of water at a temperature of (2 ± 1) °C per cm² of glazed surface (deviations defined in the VTS).

4.3.3.3.1 The gun pressure shall be held at 200 kPa $\pm$ 20 kPa or equivalent while spraying. The gun shall be held perpendicular to and at a distance of 20 cm to 25 cm from the glazed surface.

4.3.3.3.2 Stroke side to side evenly in horizontal overlapping layers, the full width of the windshield from top to bottom of the glazed surface. Each full pass of the windscreen should take 2 s to 3 s. Alternate with vertical top to bottom strokes from one side to the other. Apply water to side windows in the same fashion.

4.3.3.3.3 After the windshield and side windows have been sprayed, the frost shall be cured (soaked) for 30 minutes $\pm$ 2 minutes.

4.3.3.4 At the end of this soak period, observer enters vehicle, records a full set of data for t = 0 minutes, and confirm blower is functional without starting vehicle. Driver sets the blower to high (approximately 14 V) then starts

vehicle and confirms HVAC is set to OSA, defrost mode and full hot temperature setting. Rear HVAC blower or front auxiliary blower to remain off during this test.

4.3.3.5 Bring the wind speed to 50 km/h and accelerate vehicle speed at 3.0 km/h/s until target speed of 50 km/h is reached, then adjust throttle to maintain test speed.

Note: The engineer shall review the transmission shift map to ensure that the most likely customer gear for 50km/h is tested.

4.3.3.6 The observer shall mark and note the time of the initial breakthrough points and outline the defrosted areas on the inner surface of the windshield at 5 minute intervals from $t = 0$ minutes for a total test time of 40 minutes. A complete set of vehicle data shall be recorded at the same 5 minute intervals. A photograph of the defroster grill shall be taken at 40 minutes.

Note: Defrosted Area. See 7.1

Note: Shorter intervals for the data recording and photos are also permitted.

Windshield wipers may be operated three times at each 5 minute interval just prior to marking the windshield, if allowed in the VTS (this shall be identified on the tracings).

4.3.3.7 The tunnel operator shall record the breakthrough time for the left and right sides on the bottom of the test sheets.

4.3.3.8 Transfer the resulting pattern to a glazing surface overlay (vellum paper). Trace windshield areas (see Appendix B) and right and left side window viewing patch on the overlay for reference.

5 Data

5.1 Calculations. The cleared areas shall be calculated according to the windshield areas defined in Appendix B.

There are three methods employed to calculate the area cleared vs. time.

5.1.1 Method One (1): Calculating Areas Cleared; Using the Computer Aided Drawing (CAD) System.

5.1.1.1 Transfer the defrosted pattern from the vehicle windshield to tracing paper.

5.1.1.2 Scan or take digital picture of the traced lines.

5.1.1.3 Using a CAD system, overlay a windshield critical area template with the test result file and calculate areas cleared using the built-in pixel counting or area measurement functions in the CAD system.

5.1.2 Method 2: Calculating Areas Cleared ; Using Mass of Tracing Paper.

5.1.2.1 Transfer the defrosted pattern from the vehicle windshield to tracing paper.

5.1.2.2 Transfer the windshield critical area template onto the tracing paper containing the defroster patterns.

5.1.2.3 Cut out the driver's side clearing area template (Critical Vision Area (CVA) per Appendix B, B1), and the windshield clearing area template and weigh using a calibrated scale with an accuracy of ± 0.01 g.

5.1.2.4 Cut out the defrosted areas at the times set out in the VTS and weigh to determine mass of cleared areas.

5.1.2.5 Calculate percentage of the areas cleared using the mass of the entire template area and the defrosted areas.

5.1.3 Method 3: Calculating Areas Cleared ; Using Planimeter.

5.1.3.1 Follow the instrument manufacturer's instructions for proper usage to determine areas.

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 and defroster grille photographs shall be presented in a test report. (Reference also, Data Sheet A1 in Appendix A.)

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.

Defrosted Area: The area of the glazed surfaces having a dry surface or covered with melted or partially melted (wet) frost which can be removed from the outside surface by the wiper and washing system. It excludes the area of the surface covered with dry frost.

OSA: Outside Air mode air delivery intake valve position.

Pre-soak: Allow vehicle to cool down with hood and doors or windows open (vehicle not operating).

Side Window Defroster (SWD) Outlet: Side window defogging air outlet grill.

Soak: Allow vehicle to cool down and form ice on glazed surfaces, vehicle not operating.

Test Temperature: The test temperature is the climatic tunnel ambient as defined in 4.2.1 for the specific test condition.

Vent Outlet: An air outlet grill for the primary purpose of occupant airflow delivery to the face and torso. Located on the instrument panel, headliner or side (door) panel.

Warm-up: Vehicle warmed up at a defined dynamometer speed according to the tunnel schedule (see 4.3.1).

7.2 Acronyms, Abbreviations, and Symbols.

AT	Automatic Transmission
CAD	Computer Aided Drawing
CVA	Critical Vision Area
DTC	Diagnostic Trouble Code
GSILT	Global System Integration Leadership Team
GSSLT	Global Subsystem Leadership Team
HVAC	Heat Ventilation Air Conditioning
OSA	Outside Air
RH	Relative Humidity
rpm	Revolutions per Minute
SWD	Side Window Defroster
VTS	Vehicle Technical Specification

8 Coding System

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

Test to GMW3049