



Evaporator Condensate Management 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. Validate the vehicle evaporator condensate management performance under various static and dynamic conditions, as it relates to the vehicle passenger compartment.

1.2 Applicability. Front and/or rear passenger vehicle Air Conditioning (A/C) systems. The Road Test and the GME Static Incline Test are equivalent tests.

1.3 Remarks. The test described herein shall only be performed where conditions allow for safe handling. The road test requires severe lane changes and U-turns. Therefore proper precautions shall be taken when selecting the test roads/parking lots to ensure the safety of the driver, passenger(s) and the general public so that they are not jeopardized.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15845 GMW15775

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 Road Test. Relatively straight highway and a handling area with appropriate range to execute rapid accelerations and moderate speed turns.

3.1.4 Static Incline Test (GME Laboratory ONLY). Rain test chamber with the possibility to create a humid climate with a humidity ratio of ≥ 26 g/kg and lifting platform with adjustment facilities for lateral inclinations of 10 degrees and upgrades or downgrades of ± 15 degrees.

3.2 Equipment. See GMW15845 regarding detailed instrumentation guidance.

3.2.1 Temperature measuring and recording equipment are listed and outlined in Appendix A, Table A1.

3.2.2 Pressure measuring and recording equipment for listed measurements are outlined in Appendix A.

3.2.3 Measuring and recording equipment for listed measurements are outlined in Appendix A.

3.2.4 Measuring and recording equipment for the engine speed.

3.2.5 Measuring and recording equipment for relative humidity as outlined in Appendix A.

3.2.6 Measuring and collecting equipment for condensate from the module's drain tube spigot.

3.2.7 Timing device with a stopwatch function.

3.2.8 Recording equipment (borescope) to capture location of static and dynamic condensate.

3.2.9 Static Incline Test Only.

3.2.9.1 Device for operation and control of the engine acceleration pedal.

3.2.9.2 External fan/blower to ensure engine coolant stabilization.

3.3 Test Vehicle/Test Piece. This procedure applies to front and rear air conditioning modules installed in a vehicle. This procedure should be conducted in each vehicle development stage (mule, Integration Vehicle Engineering Release (IVER), and Product Process Validation (PPV) vehicles). The front and rear HVAC module should be prepared so that a self-lighting borescope can observe the static and dynamic condensate handling within the module. However, the HVAC module's evaporator cannot have any instrumentation on or near the evaporator surface such as a thermocouple grid, thermocouples, etc.

HVAC modules and ducts made from plastic (polypropylene and polyethylene) are best suited for this test procedure. Parts from rapid prototyping and 3D printing will not exhibit the same level of exterior condensation generation due to their material properties. HVAC modules made with rapid prototyping material can be used to understand condensate handling within the module, but test results may be misleading with respect to seam/joint integrity.

3.4 Test Time.

Calendar time: When conditions outlined in 4.2 permit.

Test hours: Will take several days to complete

Coordination hours: Not applicable

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills.

3.6.1 Road Test. One driver and one or two observer(s).

3.6.2 Static Incline Test. One operator.

4 Procedure

4.1 Preparation. The vehicle shall be prepared and equipped with devices according to 3.2 and 4.3.1. Parts which obstruct the visibility of the A/C module and related ducts shall be removed. It is highly recommended to place cameras to observe condensation formation on the outside of HVAC module and ducts.

4.1.1 Determination of Proper System Operation. Calculate the estimated amount of condensate that should be draining out of the HVAC module by following the procedure outlined in 4.1.1.1 through 4.1.1.4 or by conducting GMW15775 prior to the start of this procedure. This is to ensure the refrigerant charge of the air conditioning system is correct and that the condensate is not freezing on the evaporator core.

4.1.1.1 Disconnect the drain tube from the HVAC module drain tube spigot, and connect a hose to the HVAC module. Put the other end of a hose in a graduated cylinder capable of holding 250 mL of fluid.

4.1.1.2 Idle the vehicle for 25 minutes in Outside Air (P/OSA), vent mode, and set the temperature to full cold and collect water in the graduated cylinder for 60 s.

4.1.1.3 Calculate the theoretical amount of condensate that is to be collected (see Appendix A, Table A2).

4.1.1.4 If the amount of water collected is within 10% of the theoretical amount, reconnect the drain tube to the HVAC module drain tube spigot and proceed with the rest of the test procedure. No more condensate collection is required.

4.1.2 Settings. The vehicle ventilation system controls shall be set to Fresh Air mode Outside Air (OSA) with the windows fully closed for the entire test. If the HVAC system control logic prevents the Blower Air Inlet (BAI) from attaining 100% OSA, then the BAI door must be forced to 100% OSA mode for the duration of the test. The blower(s) switch position, temperature setting, and mode will vary during the test.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Temperature and Humidity Condition. The humidity ratio which is comprised of the temperature and humidity should be > 20 g/kg and 26 g/kg minimum for a bench test is maintained. See Appendix A, Figure A1.

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 by the Global Subsystem Leadership Team (GSSLT) Lead of Interior Airflow. Deviated requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 Road Test Roadway and Maneuvering Areas. Require a relatively straight highway with no grade for ≥ 45 km and a Parking area 0.75 km minimum long and 0.25 km minimum wide with no pedestrian or vehicle traffic.

4.2.2.2 Static Incline Test. Engine shall be set to idle at 1500 min^{-1} (1500 rpm) during the measurement period. The static incline test is to be conducted on incline angles described in Appendix C, Figure C1.

4.3 Instructions.

4.3.1 Measuring Values and Recorded Data.

4.3.1.1 Measurements in International System of Units (SI) units. See Appendix B, Data Sheet B1.

4.3.1.2 Observations and/or Recorded Video.

- Look for water droplets on the vanes of the outlets, defroster grilles, and Side Window Defogger (SWD) grilles.
- Look for water droplets or water mist in the air stream.
- Look for water droplets at the exit of the heater duct shooter nozzles.
- Look for water droplets at the module's case seams, door joints, or anywhere on the module and ducts.
- Look for water droplets on the front floor pan.
- Look for water droplets on the windshield (in Vent, Bi-Level modes only).
- Look for water droplets at or around or above all HVAC module connectors (i.e. actuators, motor controller, blower motor, sensors, etc.)

4.3.1.3 Further Data. Record in Appendix B, Data Sheet B1.

- Vehicle data, mileage and description of the system to be validated.
- Test number, date and time (time for road test only).
- Name of the person in charge of the test and the observer(s).
- List of calibrated test equipment.
- HVAC module part number and design level suffix.
- HVAC ducts part number and design level suffix.
- HVAC module and duct material used (i.e., Polyethylene, Polypropylene, Selective Laser Sintering (SLS) material).
- Drain tube part number and design level suffix.

4.3.2 Road Test Description.

4.3.2.1 Straight, Level Highway Analysis with U-turns (Windows Closed).

4.3.2.1.1 Run vehicle at a speed of 80 km/h for 30 minutes on high blower in vent mode with temperature set to full cold. If you can do so safely, make or record observations listed in 4.3.1.2.

4.3.2.1.2 When safe, slow vehicle down to a speed of 25 km/h and make a U-turn to the left. Pull to the side of the road, stop the vehicle, and make or record observations listed in 4.3.1.2.

4.3.2.1.3 Resume straight ahead travel at a speed of 80 km/h for 15 minutes.

4.3.2.1.4 When safe, slow vehicle down to a speed of 25 km/h and make a U-turn to the right. Pull to the side of the road, stop the vehicle, and make or record observations listed in 4.3.1.2.

4.3.2.1.5 Resume straight ahead travel at a speed of 80 km/h for 15 minutes. When safe, apply brakes moderately hard; i.e. rapid stop, short of squealing tires. Pull to the side of the road, stop the vehicle, and make or record observations listed in 4.3.1.2.

4.3.2.1.6 From this stop, make a Wide Open Throttle (WOT) start to a speed of 80 km/h. If you can do so safely, make or record observations listed in 4.3.1.2.

4.3.2.1.7 Stabilize at a speed of 80 km/h for 15 minutes, maintaining high blower.

4.3.2.1.8 Slow to a stop, then make a WOT start to a speed of 80 km/h. If you can do so safely, make or record observations listed in 4.3.1.2.

4.3.2.1.9 Stabilize at a speed of 80 km/h, low blower for 15 minutes. Then switch to high blower and if you can do so safely, make or record observations listed in 4.3.1.2., for two (2) minutes.

4.3.2.1.10 Repeat above test sequence as described in 4.3.2.1 through 4.3.2.9 a minimum of three (3) times in Vent mode.

4.3.2.1.11 Repeat above test sequence as described in 4.3.2.1.1 through 4.3.2.1.10 a minimum of (3) times in Bi-level mode.

4.3.2.2 Parking Area Analysis with U-turns (Windows Closed).

4.3.2.2.1 Conduct the parking area analysis in vent mode and set temperature to full cold. Idle the vehicle at low blower for 15 minutes. Accelerate rapidly to 25 km/h while changing blower switch from low to high setting. If you can do so safely, initiate a hard U-turn to the right. Make or record observations listed in 4.3.1.2.

4.3.2.2.2 Idle vehicle at low blower for 15 minutes. Accelerate rapidly to 25 km/h while changing blower switch from low to high setting. Initiate a hard U-turn to the left. Make or record observations listed in 4.3.1.2.

4.3.2.2.3 Repeat above test sequence as described in 4.3.2.2.1 through 4.3.2.2.2 a minimum of three (3) times in vent mode and set temperature to full cold door travel.

4.3.2.2.4 Repeat above test sequence as described in 4.3.2.2.1 through 4.3.2.2.3 in bi-level mode and set temperature to 50% door travel.

4.3.2.2.5 Repeat above test sequence as described in 4.3.2.2.1 through 4.3.2.2.3 in heater mode and set temperature to 50% door travel.

4.3.2.2.6 Repeat above test sequence as described in 4.3.2.2.1 through 4.3.2.2.3 in Defog (Blend) mode and set temperature to 50% door travel.

4.3.2.2.7 Repeat above test sequence as described in 4.3.2.2.1 through 4.3.2.2.3 in Defrost mode and set temperature to 50% door travel.

4.3.2.3 Static Incline Test (GME ONLY).

4.3.2.3.1 Gradient and Inclination Variation, see Appendix C, Figure C1. The entire test shall be performed in the vent (face) mode with all outlets open and windows closed. See Table 1 regarding specific test parameters. Prior to switching each vehicle orientation switch the blower setting to high.

Table 1: Vehicle Test Conditions

Section	Blower Voltage	Test Time (minutes)	Gradient Degrees	Inclination Degrees
1	Max	30	0	0
2	Low/1	60	0	0
3	Max	10	0	+10
4	Low/1	30	0	+10
5	Max	10	0	-10
6	Low/1	30	0	-10
7	Max	10	+15	0
8	Low/1	30	+15	0
9	Max	10	+15	+10
10	Low/1	30	+15	+10
11	Max	10	+15	-10

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Section	Blower Voltage	Test Time (minutes)	Gradient Degrees	Inclination Degrees
12	Low/1	30	+15	-10
13	Max	10	-15	0
14	Low/1	30	-15	0
15	Max	10	-15	+10
16	Low/1	30	-15	+10
17	Max	10	-15	-10
18	Low/1	30	-15	-10

Max Maximum

Note: Look for airborne water out of all outlets during this period. Observe system for condensate dripping from the outlets, ducts, and case seals where appropriate.

4.3.2.4 Condensate Spillage. Idle the vehicle with 1500 min⁻¹ (1500 rpm) in normal orientation (without gradient and inclination). Stabilize 15 minutes in low blower, then turn the blower off for 15 minutes, then quickly change to high blower. Look for water drops coming from the air outlets.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. The targets are defined in the Vehicle Technical Specification (VTS).

5.2.1 Straight, Level Highway Analysis. The purpose of this portion of the test is to observe the HVAC module's ability to retain condensate within the HVAC module's sump at conditions of maximum condensation generation.

5.2.1.1 Water must not accumulate in any area of the HVAC module's interior or exterior that cannot drain back through the drain tube.

5.2.2 Parking Area Analysis with U-turns. The purpose of this portion of the test is to observe several items as follows:

- Evaporator "spitting" or condensate fly-off.
- Condensation formation on the outside of the windshield at idle.
- Condensate handling within the HVAC module.

5.2.2.1 Water must not accumulate in any area of the module interior or exterior that cannot drain back through the drain tube. Condensate must not come in contact with any part of the heater core.

5.2.2.2 Monitor changes in defrost duct humidity measurements. The humidity measurements should remain constant through the duration of the test; otherwise, it is possible water is evaporating as it passes through the heater core to the defrost duct exit.

5.2.3 Static Incline Test.

5.2.3.1 The purpose of this portion of the test is to observe several items as follows:

- Evaporator "spitting" or condensate fly-off.
- Condensation formation on the outside of the windshield at idle.
- Condensate handling within the HVAC module.

Look for airborne water out of all outlets during the duration of this test. Observe system for condensate dripping from the outlets, ducts, and case seals where appropriate and record results in Data Sheet C1.

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