



Plenum - Heating Ventilation/Heating Ventilation Air Conditioning Inlet Water Ingestion (Includes Dynamic Water Separation Test)

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. This test procedure determines the ability of the plenum to manage water and the Heating and Ventilation (HV) or Heating, Ventilation and Air Conditioning (HVAC) system to resist water ingestion under various static and dynamic test conditions.

1.1.1 This procedure also includes a Wet Road Test that is only applicable to vehicles having unconventional, side mounted, ventilation inlets.

1.2 Applicability. This procedure applies to all vehicles with an enclosed passenger or sealed cargo compartment.

Note: Wet Road Test section of this procedure only applies to test vehicles with unconventional ventilation air inlets (see 1.1.1).

1.3 Remarks.

1.3.1 During dynamic tests an observer shall be required in test vehicle if a video camera is not used to monitor the HVAC air inlet for water leaks.

1.3.2 This procedure can be used for development or validation of water management.

1.3.3 This test does not evaluate all of the failure modes of plenum flapper valves. It assumes a production intent functioning flapper valve system developed by the Body Group.

1.3.4 Dynamic and Static Vehicle Airflow.

1.3.4.1 For the dynamic parts of this procedure, a driver or rear window is to be lowered 50 mm is to obtain a high negative interior body pressure for the purpose of maximizing airflow through the Blower Air Inlet (BAI). However, for some new vehicle designs, higher negative body pressure may be obtained under different conditions, i.e., all windows closed, sunroof open, etc. This should be investigated and additional tests run accordingly.

1.3.4.2 For the static parts of this procedure, the vehicle shall be tested to verify that the vehicle or buck achieves the zero body airflow (GMW3058) specified in the Vehicle Technical Specification (VTS) (maximum airflow, OSA, full cold, vent mode).

1.3.5 Dynamic tests except for the Wet Road Test are run at lower speeds since increased airflow at higher speeds can cause water from the spray bar to skip over the plenum.

1.3.6 This procedure includes the following Static and Dynamic Water Tests.

1.3.6.1 Static Test.

1.3.6.1.1 Low-Pressure Hose Washes. Simulates a home car wash.

1.3.6.1.2 High-Pressure Wand Washes. Simulates commercial high pressure hand car wash.

1.3.6.1.3 Commercial Automatic Car Washes. MPG Building 7, Touch-less Car Wash set to nominal or equivalent.

1.3.6.1.4 Spray Arches. Simulates touch-less car wash station.

1.3.6.1.6 Universal Water Test Booth (UWTB). Simulates field usage and automatic car wash.

1.3.6.2 Dynamic Test.

1.3.6.2.1 Attitude Test. Simulates vehicle in various stationary attitudes during rainstorm.

1.3.6.2.2 Shipping Angles Test. Simulates vehicle on car carrier during rainstorm.

1.3.6.2.3 Dynamic Maneuvers. Simulated during rainstorms such as: Steady State Driving, Acceleration/Braking, Lane Changes and Cornering and Snap Turns.

1.3.6.2.4 Wet Road Simulation. See 1.1.1.

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

2.3 Additional References.

- Vehicle Technical Specification (VTS).

3 Resources

3.1 Facilities. Test facilities and equipment shall be in good, safe working order. Test equipment shall have a valid calibration label affixed to it and located in a prominent place.

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 Low Pressure Hose Test. Standard water supply outlet with a capacity for delivering and measuring 30 L/minute (8 gpm) through a 16 mm (5/8 in) Inside Diameter (ID) hose. A calibrated flow measurement device is recommended to accurately measure water flow rate. Facility should be approximately level with adequate drainage capability.

3.1.4 Universal Water Test Booth. UWTB shall have capability for metering Chemfil Additive 132 or equivalent with surface tension reliever and fluorescent dye into the water being delivered to the nozzles.

3.1.5 Commercial Automatic Car Wash. Reference the Milford Proving Ground car wash or equivalent. Any equivalent car wash must have similar soap output to evaluate soap ingestion into the plenum inlet.

3.1.5.1 The facility must have one or more high-pressure oscillating soaker arches. Each arch shall have eleven nozzles, three per each side and five across the top, each nozzle producing 3.8 L/minute (1.0 gal/minute) at 6895 kPa (1100 psi).

3.1.6 Dynamic Tests. Milford Proving Ground road system, or other proving grounds proven to be equivalent, to run the dynamic road maneuvers specified in this procedure. The Circular Track at the Proving Grounds is preferred for the Steady State Speed Tests since the different directions obtained by driving in a circle will average the wind conditions. Other roads may only be used if the wind speed is < 8 km/h (5 mph) since the wind directions may not average for oval or straight tracks.

3.1.7 Attitude and Shipping Angle Tests. Equipment, roads or inclines sufficient to produce vehicle attitudes specified in 4.3.6 and 4.3.7.

3.1.8 Wet Road Test. Straight road with a sprinkling system capable of thoroughly wetting (saturating) road surface with water. Facility must have capacity to safely drive a test vehicle at speeds of 48 km/h (30 mph), 80 km/h (50 mph) and optional 113 km/h (70 mph).

3.1.10 High Pressure Wand. A wand with a nozzle producing a minimum flow of 13 L/minute (3.4 gal/minute) at a minimum pressure of 6895 kPa (1100 psi).

3.2 Equipment.

3.2.1 Trailer with system capable of storing and delivering water flow rate, set in 4.1.1, to the spray bar specified in this procedure. Trailer system must have a means of measuring the water flow rate. The water pump on the trailer must not use the vehicle battery for power since this would reduce the power available to run the vehicle HVAC blower and may affect test results.

3.2.2 Water spray bar with six (6) Nozzles.

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3.2.2.1 For static tests, six (6) Nozzles, from Spraying Systems Company, 10 mm (3/8 in) GG Full Jet Nozzle (model number QH-SS-15, or equivalent) to produce a cone-shaped spray. The nozzles are to be equally spaced. The six (6) nozzles should be spaced 190 mm (7.5 in) apart. The spray bar is to be mounted on a stand that places the nozzle orifice 100 mm (4 in) above the hood surface. The spray bar must be able to rotate the spray angle in the side view. See Appendix A, Figure A1.

3.2.2.2 For dynamic tests, six (6) Nozzles, from Spraying Systems Company, 10 mm (3/8 in) GG Full Jet Nozzle (model number 1-QG-SS, or equivalent) to produce a cone-shaped misting spray. The nozzles are to be equally spaced. The six (6) nozzles should be spaced 190 mm (7.5 in) apart. The spray bar is to be mounted on a stand that places the nozzle orifice 100 mm (4 in) above the hood surface. The spray bar must be able to rotate the spray angle in the side view. See Figure A1.

3.2.3 Equipment for determining flow rates for static hose tests.

3.2.4 Equipment for observing the HVAC air inlet for water intrusion. This may include a flashlight, mirror, fiber optic scope, etc., as desired by Engineer.

3.2.5 If a filter is used within the HVAC module or mounted above the blower air inlet where water can drip or be pushed into the module or blower, then the filter weight change will be used to verify the amount of water ingested into the blower air inlet. The filter is to be weighed before and after each test performed of this procedure. The air inlet of the module upstream of the filter is to be wiped down inside of it with a paper towel and weighed for any weight gain to verify that water pooling does not occur. If a vehicle is not equipped with a filter, then a collection bottle is required to measure for any water from the evaporator drain, the blower case cover, or any other low spot in the HVAC module. The sum of all weight changes (filter, any pooling, blower cover, etc.) are to be recorded after each test performed of this procedure and compared to the maximum specified in the Vehicle Technical Specification (VTS). The reason for doing individual weight change inspections is that the constant airflow can cause evaporation which would cause a test condition of concern to be missed if a series of conditions were being tested in a row without inspecting for differences. For example, the filter and blower air inlet are to be inspected and measured after each angle change on the tilt table so as not to miss an angle that would be a concern.

A fiber optic scope with video may also be used for validation if the video documents (in the test report) no water entering into the blower air inlet. This is the preferred method with the dynamic parts of this procedure.

3.2.6 High-pressure spray wand system equipped with 6.35 mm (1/4 in) MEG-SSTC2507 fan spray nozzle. Operating pressure set to at 12.9 L/minute (3.4 gal/minute) at 7584 kPa (1100 psi).

3.2.7 Instrument to measure acceleration and deceleration in Acceleration/Braking Test.

3.2.8 Hose for Low-Pressure Hose Test is 16 mm (5/8 in) ID.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Vehicle. Equipped with proper HV or HVAC components, ventilation relief systems and a trailer hitch.

Note: Air flow over and around the vehicle may affect pressures across the HVAC air inlet. Therefore, consider original equipment options (i.e., front hood air deflector) which may affect airflow over the hood.

Note: Consider the effect that nearby components, i.e., wiper system may have on the flow of water or air into the plenum.

3.3.2 HV or HVAC Systems. Consider running both HV and HVAC systems. Verify for design intent and proper functioning.

3.4 Test Time.

Note: Calendar time is dependent on the specific plenum and drain valve design needing validation/development.

Calendar time: (5 - 7) days

Test hours: (24 - 48) h

Coordination hours: 16 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills.

- Experienced driver having proper training for all required road tests.
- Experience and knowledge about facility operation and equipment safety.

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January 2017

Page 3 of 14



Documents
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- Water leak detection experience or training is recommended.
- Root cause analysis experience is recommended.
- Reporting: Writing, speaking and basic computer knowledge recommended.

4 Procedure

4.1 Preparation. The Engineer shall:

4.1.1 Determine the flow rates for the spray bar in the Dynamic, Attitude and Shipping Angles Tests.

4.1.1.1 For the Attitude and Shipping Angles Tests, the flow rate shall be 20 mm/minute/m² (or 0.79 in/minute/ft²) from vertical spray patterns if simulating rain or the flow rate shall be 30 L/minute (8 gal/minute if from spray bars as illustrated in Figure A1). In order to simulate the equivalent rainfall of 20 mm/minute (or 0.79 in/minute), the spray system must spray water over the total equivalent test surface area of the buck or vehicle. The equivalent area is the surface area of the vehicle projected onto a horizontal surface above the vehicle. The projected vehicle surface goes the full width of the vehicle or buck and the total fore/aft direction from a point 100 mm behind the upper edge of the windshield (or wherever water would flow "downhill" onto the windshield) to a point 50 mm forward of the leading edge of the air inlet panel (or wherever water would drain onto the air inlet panel).

4.1.1.2 For the Dynamic Test, the flow rate shall be 5.7 L/minute (1.5 GPM) from all six (6) nozzles together. The nozzles will be smaller than those used in 4.1.1.1.

4.1.2 Check the HVAC mode and temperature controls for proper functioning of system doors/dampers.

4.2 Conditions. Consult technical specifications for requirements considering the following: Any water that enters the plenum air inlet must be decided on a case-by-case basis and determined whether the water is being managed properly. Water entering through the plenum could reach the heater core, or cause damage to other components. No water on the heater core is important because there might be a possibility that water could condense on the windshield.

4.2.1 Environmental Conditions. Temperatures shall be above freezing. Wind speed shall be < 13 km/h (8 mph) constant and 19 km/h (12 mph) gusts.

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.

4.3 Instructions.

4.3.1 Low-pressure Hose Test. Perform this test under each HVAC mode setting listed in Appendix B, Data Sheet B1, section B1.1.

4.3.1.1 Tape plenum drain valves and fill plenum with water slowly to a point that is 25 mm of the blower air inlet lowest point and let the water stand for 10 minutes to see if the water level stays constant. If the water level goes down, then the leak path is to be determine and documented. Then un-tape the drain valves and return vehicle to stock and test ready condition.

4.3.1.2 Adjust water flow from a 16 mm (5/8 in) ID hose to 30 L/minute (8 gpm).

4.3.1.3 Direct water from side-to-side of vehicle, covering the plenum cover/grille area at all possible angles for 3 minutes. Hold hose outlet approximately 15 cm (6 in) away from cowl cover/grille and moving at 15 cm/s (6 in/s).

4.3.1.4 Inspect for water intrusion into the HVAC module and into the passenger compartment. Record observations and any water into the Blower Air Inlet (BAI) (see 3.2.5).

4.3.2 High-Pressure Spray Wand Test. Perform this test under each HVAC mode setting listed in Data Sheet B1, section B1.2.

4.3.2.1 Direct spray from side-to-side of vehicle to cowl cover/grille area at all possible angles for 1 minute at 15 cm/s (6 in/s). The spray orifice outlet shall be (30 ± 7.5) cm ((12 ± 3) in) away from cowl cover/grille. The fan spray shall be oriented fore-aft of the vehicle.

4.3.2.2 Inspect for water intrusion into the HVAC module and into the passenger compartment. Record observations and any water into the BAI (see 3.2.5).

4.3.3 Water Booth Test. Perform this test under each condition in Data Sheet B1, section B1.3.

4.3.3.1 Subject vehicle to Universal Water Booth as specified by engineer in 3.1.4.

4.3.3.2 Inspect for water intrusion into the HVAC modules and into the passenger compartment. Record observations and any water into the BAI (see 3.2.5).

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4.3.4 Commercial Automatic Car Wash Test. Perform this test under each condition in Data Sheet B1, section B1.4.

4.3.4.1 Conduct one car wash cycle of the commercial automatic car wash, reference 3.1.5.1.

4.3.4.2 Inspect for water intrusion into the HVAC module and into the passenger compartment. Record observations and any water into the BAI (see 3.2.5).

4.3.5 Dynamic Tests. General instructions for each dynamic test:

Note: The dynamic part that follows is for "new concepts" where there is limited experience with it or if there are large flat (nearly horizontal) areas within the plenum where water would be influenced by dynamic vehicle changes and send a "wave of water" toward the BAI. Dynamic Test (4.3.5) is optional if the type of plenum under consideration has been shown to be robust to dynamic changes of getting any water into the BAI. Before any parts of 4.3.5 of this procedure is run, the platform and the HVAC Vehicle Performance Owner Engineer must agree to the need to run this test and specifically request that it be done.

- a. Locate spray bar on hood per Figure A1. The spray bar should direct water spray to the center of the gap between the hood and windshield with vehicle not moving (Point A in Figure A1). The tip of the nozzles near center line of vehicle should be a distance of 240 mm from Point A in Figure A1.
- b. Open driver's window 50 mm (2 in) and close all other windows. See 1.3.4 for additional information.
- c. Adjust water flow rate to 5.7 L/minute (1.5 gal/minute) per 4.1.1.2.
- d. Perform 4.3.5.1 through 4.3.5.4 maneuvers under each condition in Data Sheet B1, section B1.5. Inspect for water intrusion into the HVAC module and into the passenger compartment after each event. Record observations and any water into the BAI (see 3.2.5).

4.3.5.1 Steady State Speed. Drive vehicle on Circular Track (see 3.1.6).

- a. One lap at 50 km/h (30 mph).
- b. One lap at 70 km/h (45 mph).
- c. One lap at 90 km/h (55 mph).
- d. Record observations and any water into the BAI (see 3.2.5).

4.3.5.2 Acceleration/Braking. Drive vehicle to appropriate road system and do the following:

- a. If plenum is dry, turn on spray bar for 1 minute to wet the plenum for consistent surface tension to improve repeatability.
- b. Accelerate to 70 km/h (45 mph).
- c. Allow water in plenum to stabilize for 15 s.
- d. Perform a Moderate Brake Application from 70 km/h (45 mph) to a complete stop.
- e. Immediately, make a Moderate Acceleration back to 70 km/h (45 mph).
- f. Allow water in plenum to stabilize for 15 s.
- g. Repeat braking and acceleration one more time. This will be a total of two cycles of moderate braking.
- h. Accelerate to 70 km/h (45 mph).
- i. Allow water in plenum to stabilize for 15 s.
- j. Make a Maximum Rate Brake Application from 70 km/h (45 mph) to stop.
- k. Immediately, accelerate at wide open throttle (do not spin tires) back to 70 km/h (45 mph).
- l. Allow water in plenum to stabilize for 15 s.
- m. Repeat braking and acceleration one more time. This will be a total of two cycles of maximum braking.
- n. Record observations and any water into the BAI (see 3.2.5).

4.3.5.3 Lane Changes. Do the following:

Note: Sudden lane changes are allowed only on certain Proving Grounds tracks.

- a. If plenum is dry, turn on spray bar for 1 minute to wet the plenum for consistent surface tension to improve repeatability.
- b. Obtain steady speed of 70 km/h (45 mph).
- c. Allow water in plenum to stabilize for 15 s.
- d. Make a sudden lane change from left-to-right as in an avoidance situation.