



Side Window and Outside Rearview Mirror Glass Contamination

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. Evaluation of side window and outside rear view mirror glass contamination.

1.2 Applicability. For full scale vehicles and passenger cars.

1.3 Remarks. Investigations of contamination of side windows and outside rearview mirrors are conducted to keep a clear view from the driver's seat through the side window onto the outside rearview mirror even under heavy rain conditions and dirty roads, to maintain vehicle safety.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14264 GMW14459 (ID)

(ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

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.

3.2 Equipment.

3.2.1 Multiple Jet Spray Rig.

3.2.1.1 Multiple Jet Spray Rig in the Wind Tunnel.

3.2.1.1.1 Water Spray Rig. A rig with three spray jet nozzles spaced 0.5 m apart is mounted stationary on a frame structure in front of the vehicle on the wind tunnel floor. The position of the jets is at headlamp height, ≈ 0.75 m distance to the floor, and ≈ 1.5 m in front of the vehicle. The spray jets are directed against the main air flow (see Figure A1 in Appendix A).

3.2.1.1.2 Tracer Fluid. A mixture of water and fine chalk powder is used to visualize the water flow around the vehicle. The chalk powder must be finely ground, typically with a median particle diameter $< 3 \mu\text{m}$ (e.g., "Champagne chalk"). The ratio of water to chalk powder is approximately 17:1 by volume. This mixture is chosen to simulate on the vehicle's surface a heavy, rain-like flow behavior as well as driving over an ≈ 200 km long distance of muddy soiled winter roads.

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If the chalk mixture cannot be used in the wind tunnel due to airpath contamination, a solution of fluorescent dye may be used. Example dyes are Day-Glo D-282 UV-blue optical brightener and Ciba Uvitex. The solution ratio is 400:1 by volume. It is helpful to dissolve the dye in a small quantity of hot water and then to mix it into the bulk solution.

3.2.1.1.3 Water Container and Pump. A container with an electrically powered fluid pump is used for mixing and pumping the tracer fluid. The pump capacity and nozzle sizes shall be selected to provide atomized flow at 7.2 L/minute. The container is connected with small bore rubber hoses to carry the tracer fluid from pump to spray jet nozzles. A means to stir or recirculate the tracer fluid between tests should be provided, to prevent settling of the mixture.

3.2.1.1.4 Ultraviolet Lights. If the fluorescent dye solution is used during tests in the wind tunnel, ultraviolet lights are used to illuminate the side window and mirror area, to cause the dye to glow. The wind tunnel lights must be turned off during the test and photography.

3.2.1.1.5 Remote Control of Wipers. Remote control of windshield wipers is driven by an external transformer (12 Voltage direct current (VDC)). If the connections to an external transformer cannot be accomplished (i.e., competitor vehicles), the wipers are controlled by a person sitting in the driver's seat during the test.

3.2.1.1.6 Traffic Sign. To aid the evaluation of the visibility through the side window into the rearview mirror, a traffic sign is located behind the vehicle in such a way that it can clearly be seen in the rearview mirror, see Figure D2, Appendix D.

3.2.1.2 Multiple Jet Spray Rig on the Vehicle on the Road.

3.2.1.2.1 Water Spray Rig. A rig with three spray jet nozzles spaced 0.5 m apart is mounted stationary on a frame structure on the front of the vehicle. The position of the spray jet nozzles is ≈ 1.5 m in front of the vehicle at headlamp height (≈ 0.75 m distance to the road surface). The spray jets are directed with the travel direction (see Figure B1 in Appendix B).

3.2.1.2.2 Tracer Fluid. A mixture of water and fine chalk powder is used to visualize the water flow around the vehicle. See paragraph 3.2.1.1.2.

3.2.1.2.3 Water Container and Pump. A container with an electrically powered fluid pump is used for mixing and pumping the tracer fluid. The pump capacity and nozzle sizes shall be selected to provide atomized flow at 7.2 L/minute. The container is connected with small bore rubber hoses to carry the tracer fluid from pump to spray jet nozzles. A means to stir or recirculate the tracer fluid between tests should be provided, to prevent settling of the mixture. It is located in the rear compartment or in the trunk of the test vehicle. Alternatively, a gas-powered pump system may be towed behind the test vehicle.

3.2.1.2.4 Control of Wipers. The windshield wipers and washer may be controlled remotely or by the driver.

3.2.2 Single Jet Spray Rig. A single jet spray device is used in the wind tunnel as well as on the road.

3.2.2.1 Water Spray Jet. A brass jet nozzle with jet adjustment is mounted on an aluminum bracket. The jet device is fixed by means of a double-sided tape at two special positions to investigate two specific kinds of contamination (see Figure C1 in Appendix C):

- On top of the hood in the rear side area in such a way that the jet is directed centrally to the outside rearview mirror housing, and
- On the outboard mirror glass surface of the outside rearview mirror in such a way that the jet is directed towards the side window.

The diameter of the sprayed area is in each case ≈ 200 mm.

3.2.2.2 Spray Liquid and Liquid Canister. The spray liquid, a mixture of water and screen-clean (soap), is carried in a 10 L plastic canister in the vehicle.

3.2.2.3 Water-Pump. A 12 V windshield washer pump (power from the cigarette lighter) pumps the water from the canister to the spray jet. The power can be switched on and off by a push button switch in the power cable.

3.3 Test Vehicle/Test Piece.

3.3.1 Vehicle Description. Full-scale models with fully represented body contours, outside rearview mirror housing with glass, engine, chassis, drive train, and detailed underbody, as well as prototypes and production vehicles shall be investigated in the wind tunnel.

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3.3.2 Vehicle Equipment. Vehicle equipment corresponds to the equipment according to the latest status of product program including all options that are relevant for side window contamination, i.e., A-pillar, A-pillar molding, door frame, seals, outside rearview mirror housing with mirror glass.

3.3.3 Trim Height. At the beginning of a test session, trim heights of the vehicle are set according to the trim height sheet between unloaded and loaded according to GMW14459. A variation within this bandwidth is allowed. Measured trim heights have to be recorded.

3.4 Test Time.

Calendar time: 1 day
Test hours: 8 hours
Coordination hours: 16 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills.

- Aerodynamics performance engineer: Understanding of aerodynamics theory and best practices.
- Wind tunnel operator: Proficiency in operation of wind tunnel equipment and data acquisition.

4 Procedure

4.1 Preparation.

4.1.1 Vehicle.

4.1.1.1 Position of Driver's Seat. Driver's seat shall be adjusted to a comfortable position of the driver.

4.1.1.2 Positioning of Outside Rearview Mirror Glass. Prior to a test session, outside rearview mirror glass shall be positioned to the driver's viewing position.

4.1.1.3 Definition of Driver's Field of Vision through Side Window. Driver's vision line through side window onto the complete fringe of outside rearview mirror glass marks a field of vision on the side window which needs to be free of contamination under driving conditions for every velocity. The fringe of field of vision is highlighted with a narrow self-adhesive tape on the inside of the side window.

The size of field of vision depends on the size of the outside rearview mirror glass but also on the individual size of the driver. The rearmost boundary (i.e., length of field) on the actual test vehicle is determined when the driver puts the seat into the rearmost position and looks onto the outermost fringe of the mirror glass. The topmost and lowermost fringe is determined by moving the seat up and down or by nodding the head. The foremost boundary is determined by moving the seat into the foremost position and looking on the inner fringe of the mirror glass. As an example, Figures D1 and D2 in Appendix D show the field of vision on the side window of a vehicle.

4.1.1.4 Heated Outside Rearview Mirror Glass. If the vehicle is equipped with an electrically heated outside rearview mirror, heater shall be shut off during vehicle testing.

4.1.1.5 Closing of Openings and Gaps when the Vehicle is in the Wind Tunnel. Front end openings and gaps as well as gaps around doors (except door on driver's side), and windows may be closed by adhesive tape to reduce inner vehicle contamination to a minimum. However, it is preferred to leave the front end open to avoid affecting the airflow patterns over the front of the vehicle and approaching the mirror and side window. Attention should be paid that gaps which are relevant for contamination and can catch water are not closed. Examples of such gaps are doors without secondary seals to A-pillar and door frame and gaps around hatch doors in the rear of the vehicle.

4.1.2 Wind Tunnel.

4.1.2.1 Vehicle Installation. The vehicle is aligned parallel to the air stream. The position of the water spray jet nozzles is ≈ 1.5 m in front of front bumper; see paragraph 3.3 and Appendix A.

4.1.2.2 Visualization Systems.

4.1.2.2.1 Multiple Jet Spray Rig. See 3.2.1.1.

4.1.2.2.2 Single Spray Jet. See 3.2.2.

4.1.2.3 Recording Systems.

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4.1.2.3.1 Video Camera. For documentation and later evaluation purposes a camera with video capability is installed outside the wind tunnel airflow. The camera is directed to that part of the vehicle which shows a part of windshield, A-pillar, and side window on the driver's side.

4.1.2.3.2 Still Photo Camera. A camera with still photo capability is installed/available outside of the vehicle. It may be the same camera that is used for video.

4.1.2.3.3 Camera inside Vehicle. A camera is available or mounted inside the vehicle, aimed toward the side window and mirror from the driver's perspective. The camera may be used for video or still photos during the test.

4.1.3 Vehicle on the Road.

4.1.3.1 Installation of Multiple Jet Spray Rig. See 3.2.1.2.

4.1.3.2 Installation of Single Spray Jet Device. See 3.2.2.

4.1.3.3 Recording Systems.

4.1.3.3.1 Video Camera. For documentation and later evaluation purposes a camera with video capability is operated by a passenger or mounted inside the vehicle, aimed toward the side window and mirror from the driver's perspective.

4.1.3.3.2 Still Photo Camera. A camera with still photo capability is available for use inside or outside of the vehicle. It may be the same camera that is used for video.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Temperature in the Wind Tunnel. The temperature during wind tunnel testing shall be between +20 °C and +30 °C.

4.2.1.2 Temperature on the Road. The temperature during on-road testing shall be between +5 °C and +35 °C.

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 Tracer Fluid. See 3.2.1.1.2. In advance of every test, the pump is activated and the fluid is mixed additionally by shaking the complete tank.

4.3.2 Wind Speed.

4.3.2.1 Standard Speed Steps in the Wind Tunnel/on the Road. Tests are conducted within a wind speed range from 50 km/h to 120 km/h. Four standard wind speeds are used: 50 km/h, 80 km/h, 100 km/h, and 120 km/h.

4.3.2.2 Further Speeds in the Wind Tunnel/on the Road. Regular checks over the whole speed range shall be performed to ensure that no unexpected effects are discovered at intermediate wind speeds. In general, documentation is unnecessary during this test.

4.3.2.3 Further Spraying Time in the Wind Tunnel/on the Road. Regular checks with longer spraying time shall be performed to ensure that no unexpected effects are discovered at different spraying times. In general, documentation is unnecessary during this test.

4.3.3 Yaw Angle.

4.3.3.1 Standard Yaw Angle in the Wind Tunnel. Standard yaw angle is 0 degrees. Further yaw angles may be studied.

4.3.3.2 Ambient Wind on the Road. To minimize the effects of yaw angle, ambient wind is to be < 10 km/h.

4.3.4 Multiple Jet Spray Rig.

4.3.4.1 Wind Tunnel. When accelerating wind tunnel airflow to the correct wind speed, the tracer fluid is mixed by means of the pump in the tank. After having reached correct wind velocity, valves are operated so that the tracer fluid is sprayed by means of the pump into the airflow directly ahead of the vehicle.

Complete spraying time is 20 s. While spraying, the wiper system is switched on at the lowest continuous speed. Between the 18th and 20th second (i.e., during the last 2 s of spraying), the windshield washer system is also switched on.

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When spraying stops after 20 s the wind tunnel is left running until the side window is nearly dried in order to avoid the mixture running down the glass.

4.3.4.2 Road. After having intensively mixed the tracer fluid, the vehicle is accelerated to the desired velocity and the contamination test begins.

Spraying time is 20 s. While spraying, the wiper system is switched on at the lowest continuous speed. Attention shall be paid that the wiper system is activated before the spray system is switched on. Between the 18th and 20th second (i.e., during the last 2 s of spraying), the windshield washer system is also switched on.

When spraying stops after 20 s, driving is continued with constant velocity until the side window is nearly dried in order to avoid the mixture running down the glass.

4.3.5 Single Jet Spray Rig.

4.3.5.1 Investigation of Water Droplets Falling Down From the Outside Rearview Mirror Housing. Separation and falling down of water droplets from the outside rearview mirror housing can be investigated with a single jet spray device fastened at the rear side of the hood.

4.3.5.2 Investigation of Self Cleaning of the Field of View through Side Window. The time that water droplets remain on the outside rearview mirror glass and on the side window can be investigated with a spray jet nozzle fastened at the outmost area of outside rear view mirror.

4.3.6 Documentation.

4.3.6.1 Wind Tunnel.

4.3.6.1.1 Video. Prior to a test, a data sheet with test number and specific vehicle configuration and title (see Table E1 in Appendix E) shall be documented with the video camera.

The flow around/over the side window is recorded by the video camera described in paragraph 4.1.2.3.1. The flow is recorded just after the wind has reached the desired wind speed, before, during, and after the spray cycle. The video is used for documentation and for later evaluation.

4.3.6.1.2 Still Photos. During the test, photos or video are taken with the camera inside the vehicle, described in paragraph 4.1.2.3.3.

When the wind stops, the side window and mirror contamination of the vehicle is documented with the following photos:

- From inside the vehicle, the driver's view through the side window into the outside rearview mirror. In order to improve the evaluation of the contamination rate shown in the outside rearview mirror glass, a traffic sign (e.g., "STOP" sign) was placed on a predefined position behind the vehicle in such a position that it can be seen in the rearview mirror. The traffic sign is illuminated from the front in order to get a clear picture in the outside rearview mirror (see Appendix D).
- From outside the vehicle, a picture of the complete A-pillar and side window area.
- From outside the vehicle, a picture of the mirror glass. For this photo, it is helpful to cover the side window with a black drape (e.g., a garbage bag or cloth) to eliminate reflections of the contamination on the window.

For better later identification and classification of the pictures, it is recommended to label the test number and wind velocity on the inner side as well as on the outer side of side window before photographing.

4.3.6.2 Road.

4.3.6.2.1 Video. The flow around/over the side window is recorded by a video camera inside the vehicle. The flow is recorded just after the wind has reached the desired wind speed, before, during, and after the spray cycle.

4.3.6.2.2 Still Photos. Still photos are taken per 4.3.6.1.2.

5 Data

5.1 Calculations. The average grade of contamination of a test at one velocity is calculated as follows:

Every single criterion of the above five criteria is judged for itself. After this it is multiplied by the weighting factor. The sum of all the single weighted grades gives the rating for a given speed.

The average grade for a complete test is calculated as the arithmetic average of all grades for the four (4) specified velocities.

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