GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW17026

Accelerated Corrosion Laboratory Test for Galvanic Corrosion Mechanisms

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 standard describes an accelerated corrosion test. This test is designed for corrosion replication especially where galvanic corrosion mechanisms are present.

1.2 Applicability. This procedure is applicable to passenger car and truck, SUV and Crossover, and commercial vehicle components or assemblies.

1.3 Remarks. This is a cyclic environmental test which exposes test samples to periodic wetting with a salt/mud solution followed by drying all at an elevated temperature.

2 References

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

2.1 External Standards/Specifications.

ASTM D1193 ISO 8407 SAE J2329

2.2 GM Standards/Specifications.

GMW14700 GMW15282

2.3 Additional References.

- Component Technical Specifications (CTS)
- Material Specifications
- Part Drawings
- Subsystem Technical Specifications (SSTS)

3 Resources

3.1 Facilities. Floor space adequate for appropriate corrosion chamber, fixturing, controls, and pneumatic capability.

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 Test Chamber. A test chamber is required that is of sufficient size to contain the test samples with adequate space for air and solution circulation around them. It is recommended that the size be approximately 1 m × 1 m× 2 m (3 ft × 3 ft × 6 ft). The chamber must be constructed of materials which are resistant to corrosion such as stainless steel or plastic. Likewise, all fittings, hardware and attachments must be corrosion resistant. It is extremely beneficial if the test chamber has windows for observing testing while in progress. The test chamber must have available pass-throughs for sampling and/or instrumentation connections. The test chamber must be designed so that the test solution will drain back to the test solution reservoir.

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3.2.1.1 Solution System. The chamber must have a solution circulating pump and spray system capable of spraying the water/salt/mud mixture in a consistent and reliable manner. The test solution reservoir must have agitation to maintain the solids dispersion.

3.2.1.2 Spray System. Spray systems should spray from a direction corresponding to vehicle tire patch(s) or other locations where spray would originate on a vehicle. Spray pumps are usually pneumatic powered for use in the corrosive environment. The spray pumps are a pulse type, not a continuous spray, with large droplets (approximately 2 mm to 4 mm diameter). The initial spray volume at each nozzle should be between 1.5 L/minute and 3.0 L/minute.

3.2.1.3 Heating System. The test chamber must have a heating and control system capable of maintaining a constant temperature of (66 ± 3) °C uniformly throughout the test sample space in the chamber. The only exception to this is during the first 60 minutes after spray events when the temperature will have dropped and must recover. The temperature is measured at the closest available location to the test samples. The test chamber must have provisions to circulate heated air within the chamber. A fan turning at 900 rpm to 1800 rpm is usually sufficient.

3.2.1.4 Vent System. The test chamber must have provisions for venting or purging the atmosphere in the chamber. Pneumatic actuators controlling the vents are sufficient for use in the corrosive environment.

3.2.2 Chamber Control.

3.2.2.1 Chamber Temperature Controller. The controller must be able to vary the temperature with time in order to create temperature cycles from a given external command. The controller timing functions must be controlled to ± 1 s. The test chamber must have a heating and control system capable of maintaining a constant temperature of (66 ± 3) °C uniformly throughout the test sample space in the chamber.

3.2.2.2 Chamber Vent Controller. The controller must be able to open and close pneumatic, or otherwise, actuators on the vent(s) on the top of the booth.

3.2.2.3 Chamber Spray Controller. The controller must be able to start and stop the spray system pump solenoids.

3.2.3 Test Solution Reservoir. The reservoir must be sized to hold sufficient solution to support the spray system in the chamber. Generally, a 100 L to 200 L tank will support a 1 m × 1 m× 2 m (3 ft × 3 ft × 6 ft) chamber with up to 20 spray nozzles. The reservoir must have agitation to maintain the solids in suspension for uniform spray application to the test samples. The reservoir and its associated plumbing and pumps must be able to handle the water/salt/mud mixture that is the test solution. Adequate screening and filtering are required to prevent large stones and debris from damaging the pump and/or plugging the system.

3.2.4 Air Supply. The compressed air supply used to atomize and spray the corrosive solution in the chamber must be free of oil and dirt and controllable between 70 kPa and 500 kPa (10 psi and 70 psi).

3.2.5 Corrosion Coupons and Mounting Hardware. Coupons serve to monitor the general corrosion produced by the test environment. Coupons consist of 25.4 mm wide × 50.8 mm long × 3.18 mm thick pieces of bare SAE 1008-1010 cold rolled carbon steel per SAE J2329 CR1E, which are stamped with an alphanumeric identification number (reference Appendix A, Figure A1).

The coupons shall be secured to an aluminum or non-metallic coupon rack with fasteners as shown in Appendix A, Figure A2. The bolt, nut and washers shall be made from a non-black plastic material, preferably nylon. Appendix A, Figure A3 shows a completed coupon rack configuration. The number of coupons recommended are at least 12 per test for a 10 year exposure, and 18 for a 15 year exposure, and are shown for different test durations in Appendix A, Table A1.

3.3 Test Vehicle/Test Piece. The test samples can be anything from test panels to complete components and/or subassemblies. Expose the test sample in vehicle position in the test chamber to achieve the most realistic exposure. It is sometimes desirable to pre-damage the specimens before testing to simulate field exposure. Scribes through the paint coating, as specified in GMW15282, or chipping from GMW14700 exposure are two of the more common techniques.

The number of samples required to test should be enough to provide adequate statistical data at the required confidence level.

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3.4 Test Time. See Table 1.

Table 1: Test Times

Exposure	Method 1	Method 2
10 Years	(50 ± 12) d	(38 ± 9) d
15 Years	(75 ± 18) d	(59 ± 14) d

Note: 1 d (Day) = 2 Cycles = 8 Segments, Time to run one (1) segment = 3 h.

3.5 Test Required Information. Information required from customer: Sample orientation, inspection intervals, and the data that needs to be collected at each interval, along with any relevant performance requirements.

3.6 Personnel/Skills. Test personnel familiar with test facilities and equipment.

4 Procedure

4.1 Preparation.

4.1.1 Test Solution. The solution can be prepared by volume or weight. Instructions for this follow. Instructions and some example batch mixture formulae are also shown in Appendix B, Table B1.

4.1.1.1 Test Solution by Volume. Fill a cleaned and rinsed tank with 200 L of reverse osmosis (RO) conforming to ASTM D1193, Type IV. Turn on the agitator pump. Add 5200 mL Sodium Chloride. Sodium Chloride must be reagent grade or Morton Culinox 999 Food grade. Add 2600 mL Fireclay. Sources of Fireclay are listed in Appendix C.

4.1.1.2 Test Solution by Weight Alternative. Alternately, the solution can be prepared in a two-step procedure. First a 3% salt solution is prepared by dissolving three (3) parts by weight of sodium chloride in 97 parts of reverse osmosis water to achieve a 3.0% by weight sodium chloride solution per specification ASTM D1193, Type IV. Sodium Chloride must be reagent grade or Morton Culinox 999 Food grade. Second, to each 1.0 kg of salt solution, add 0.317 kg of Fireclay (or to each 1.0 lb of salt solution, add 0.317 lb of Fireclay). Sources of Fireclay are listed in Appendix C.

4.1.1.3 Test Solution Maintenance. The salt concentration in the solution shall be checked initially when made and at approximately 2 (general corrosion) test year intervals and maintained at (3.0 ± 1.0)%, with the intent of maintaining as close as possible to 3.0%. These measurements shall be made either electrochemically or gravimetrically. The pH of the solution as sprayed in the chamber shall be maintained between 6.0 and 8.0, with the intent of maintaining as close as possible to 7.0.

4.1.2 Coupon Preparation. Corrosion coupons must be cleaned prior to use. One (1) option is to use pressure washing to remove processing fluids, then clean in an Ultrasonic cleaner, followed by a RO water rinse and hand drying. The initial mass, in grams (g), shall be recorded and retained for future reference. If coupons are not used immediately, coupons should be stored such that the coupons are corrosion-free at the start-of-test (SOT).

It is critical that all forming or preservation oils/lubes be removed prior to exposure to allow for general/uniform corrosion of the coupon.

4.1.3 Coupon Rack Preparation. Prior to start-of-test; prepare a coupon rack with sufficient coupons to monitor the test. Sufficient coupons shall be enough to allow at least two coupons to be removed after data collection point, as listed in Appendix A, Figure A6. The recommended number of coupons is listed in Appendix A, Table A1.

The exact location of each coupon on the rack shall be identified and recorded using the pre-stamped numbers for reference.

Allow a minimum 5 mm spacing between the coupons and the rack surface. All coupons shall be secured vertically with no more than 15 degrees angle rearward deviation from vertical (as shown in Appendix A, Figure A3) and must not contact each other.

The coupon rack shall be placed in the general vicinity of the samples being tested, such that the coupons receive the same environmental exposure as the test samples.

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Sources of coupons and coupon racks are listed in Appendix C.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

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. The test chamber is operated 24 h/day on the following 3 h wet/dry cycle (or "block"):

4.3.1 First the test chamber temperature is set to 66 °C and vent is set to closed. Then a 3 minute corrosion solution spray is performed. After the minimum 3 minute spray, the vent is opened for remainder of 90 minutes (87 minutes) to dry the test samples. After 90 minutes, the vent is closed, and it remains closed for another 90 minutes (180 minutes total), at which point the sequence (block) repeats.

4.3.2 The time histories of the vent, spray, and temperature are shown in Appendix A, Figure A4. A Flow Diagram for the steps that comprise one (1) cycle of the test method is shown in Appendix A, Figure A5. Repeat the daily cycle (8 blocks) as necessary to complete the requested exposure.

4.3.3 This is a cyclic corrosion test which consists of wet and dry periods at elevated temperature. Any variation from the basic test schedule must be agreed upon between the test requestor and the tester and be reported in detail in the final report.

4.3.4 Test samples must be placed in the chamber in a manner that ensures all samples receive an equal and representative quantity of test solution during the spray portion of the cycle. The samples must also be oriented to avoid shielding other samples or trapping unrealistic quantities of test solution.

4.4 Test Environment Monitoring. Corrosion coupons shall be removed and analyzed throughout the test to monitor the corrosion exposure. Recommended data collection points would include 1, 3, 5, 10, and 15 years exposure to monitor test progress. To analyze coupons, remove two (2) coupons, one (1) coupon from each end of the coupon rack, clean per 4.4.1 to prepare for weighing, and calculate an average mass loss using the initial mass loss data collected in 4.1.2.

Note: Although not preferred, corrosion by-product removal by chemical cleaning per ISO 8407 may be used.

4.4.1 Coupon Preparation. Before weighing, clean the coupons using a mild sand/bead blast process to remove all corrosion by-products from the coupon surface. Wipe the coupons free of grit and weigh to determine the coupon mass loss using the following formula:

Mass Loss = (Initial Mass) – (End-of-Exposure Mass)

4.4.2 Coupon Mass Loss. See Table 2 (Method 1) and Table 3 (Method 2).

Table 2: End of Test Coupon Mass Loss Targets for Method 1

Exposure	Method 1		
	Days	Cycles	Mass Loss
10 Years	(50 ± 12) d	(100 ± 24) cycles	(9.5 ± 2.38) g
15 Years	(75 ± 18) d	(150 ± 36) cycles	(13.25 ± 3.31) g

Table 3: End of Test Coupon Mass Loss Targets for Method 2

Exposure	Method 2		
	Days	Cycles	Mass Loss
10 Years	(38 ± 9) d	(76 ± 18) cycles	(7.23 ± 1.81) g
15 Years	(59 ± 14) d	(118 ± 28) cycles	(10.84 ± 2.71) g

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Note: Desired coupon mass losses corresponding to incremental test durations (reference 4.4) are plotted on the chart in Appendix A, Figures A6 and A7. To check test progress, compare the actual mass loss to the targeted values plotted on the chart in Appendix A, Figures A6 and A7. If the actual mass loss does not fall within the plotted range of acceptable values at end of test, the test requestor shall be notified of the deviation. Also, the reasons why the target mass loss value was not obtained shall be investigated and corrected before resuming the test.

4.5 Inspection. The test sample(s) shall be inspected per the test request and photographed (as necessary) at the requested sample inspection intervals. If test samples containing plastic materials are being tested, any discoloration or degradation and/or adhesive bond failure (delamination) shall be noted and recorded.

4.6 End-of-Test (EOT). At EOT, the samples may be rinsed with fresh tap water and allowed to dry before evaluating.

5 Data

5.1 Calculations.

5.1.1 Salt solution (reference Appendix B, Table B1).

5.1.2 Calculate mass loss (reference 4.4.1).

5.2 Interpretation of Results. The test procedure is best suited for comparative testing where an item of known performance baseline is tested along with the item of interest. Absolute test results must be viewed with care and referred to past tests.

5.2.1 Acceptance Criteria. Acceptance criteria shall be specified within engineering documentation which includes: Material Specifications, SSTS, CTS, and part drawings.

5.3 Test Documentation.

5.3.1 Coupons. Coupon mass loss values are to be recorded throughout the test to the completion of the desired test exposures. Data may be plotted on charts like the examples found in Appendix A, Figure A6.

5.3.2 Test Samples. Test reports shall include summaries of the sample data and test results, number of cycles run, coupon mass loss data and any deviations to the test.

5.3.3 Test Equipment. The following information shall be recorded and available upon request for each cabinet/exposure location used to conduct the test or gather data. The test equipment recording is done using the Test Equipment Recording Sheet (refer to Appendix D, Data Sheet D1 for an example). The supplier shall work with the GM Lead Engineer to comprehend these requirements.

5.3.3.1 Booth number.

5.3.3.2 Test site controller number.

5.3.4 Test Solution. The following information shall be recorded and available upon request:

5.3.4.1 Frequency of Salt Solution Changes.

5.3.4.2 Weekly pH of Solution.

5.3.4.3 Weekly Salinity or Conductivity of Solution.

5.3.4.4 Initial Solution Constituents.

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.

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