GM WORLDWIDE ENGINEERING STANDARDS	Test Procedure	GMW15264

Accelerated Corrosion Laboratory Test with Dynamic Simulation Option

1 Scope

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 that can be combined with mechanical, electrical, and/or pneumatic inputs with environmental (chemical and thermal) inputs to produce realistic vehicle part or system wear and aging. This test is designed for corrosion replication of functional incidents and where galvanic corrosion mechanisms are present.

1.2 Foreword. This is a cyclic environmental test, which exposes test items to periodic wetting with a salt/mud solution followed by drying all at an elevated temperature. If requested, forces or other dynamic inputs should be applied in a realistic manner consistent with the function of the item under test. The test requestor must define the test duration and the required component loading based on anticipated failure mechanisms and acceleration rates.

1.3 Applicability. This procedure is applicable to passenger car and truck components or sub-assemblies. This test has shown good test-to-field correlation of accelerated galvanic corrosion with dynamic inputs.

2 References

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

2.1 External Standards/Specifications.

ASTM D1193 SAE J2329

ISO 8407

2.2 GM Standards/Specifications.

GMW14700 GMW14868

GMW14794 GMW15282

2.3 Additional References.

- Component Technical Specifications
- GMU Course No. 29989 Hydraulic Testing Fundamentals
- Material Specifications
- Part Drawings
- SAE 1008-1010 Carbon Steel
- Subsystem Technical Specifications

3 Resources

3.1 Facilities. Bedplate space adequate for appropriate corrosion chamber, fixturing, and controls with appropriately 3000 psi hydraulic and/or 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 items with adequate space for air and solution circulation around them. It is recommended that the size be approximately 1 m x 1 m x 2 m. 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 dynamic fixturing, sampling and/or instrumentation connections. The test chamber must be designed so that the test solution/slurry will drain back to the reservoir.

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

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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 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 uniform temperature (±3 °C) at 66 °C, the only exception being the first 60 minutes after spray events. The temperature is measured at the closest available location to the test parts. The test chamber must have provisions to circulate heated air within the chamber. A vehicle fan turning at 900 rpm to 1800 rpm is 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 the best 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 uniform temperature (±3 °C) at 66 °C.

3.2.2.2 Chamber Vent Controller. The controller must be able to signal solenoids to open and close 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 pneumatic 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 150 L tank will support a 1 m x 1 m x 2 m 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 slurry that is the test solution. Adequate screen and filter are required to prevent large stones and debris from damaging pumps 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.

3.2.5 Corrosion Coupons and Mounting Hardware. Coupons serve to monitor the average general bare steel corrosion produced by the test environment. Coupons consist of 25.4 mm wide x 50.8 mm long x 3.18 mm thick pieces of bare SAE 1008-1010 carbon steel, cold rolled steel per SAE J2329 CR1E, uncoated, no post coating treatment, 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 for different test durations are shown in Appendix A, Table A1.

3.3 Test Vehicle/Test Piece. The test specimens can be anything from test panels to complete components and/or subassemblies. Expose the test specimen in the vehicle position in the test chamber to achieve the most realistic exposure. Assure that any actuation of the test specimen accurately represents the actual field operation and that the mechanism does not influence the test.

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

Note: Any actuators or mechanisms which are installed in the chamber to exercise the test specimen must be resistant to severe corrosion 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 and gravelometer exposure GMW14700 are two of the more common techniques.

3.4 Test Time.

Calendar time:	50 days
Test hours:	1200 hours
Phase hours:	120 hours
Cycle hours:	12 hours
Block hours:	3 hours

A cycle is defined as 1% of test.

An option to run to 15 years (150%) of test is available. Calendar and test hours listed would be multiplied by 1.5.

3.5 Test Required Information. Information required from customer: Dynamic cycling requirements include loads, stroke lengths,

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repeats, accelerations, or any desired parameter needed to control and run the simulation.

3.6 Personnel/Skills. Personnel operating or assembling hydraulics should have at a minimum an exposure to hydraulics, and have completed the on-line Hydraulic Testing Fundamentals GMU course number 29989 or equivalent training.

4 Procedure

4.1 Preparation.

4.1.1 Test Solution. The solution is prepared by volume. Instructions for this follow.

4.1.1.1 Test Solution by Volume. Fill a cleaned and rinsed tank with 200 L tank (within one inch of the top of the tank lid extension) with reverse osmosis (RO) water conforming to ASTM D1193, Type IV. Turn on the agitator pump. Add 5.7 kg of sodium chloride. Sodium Chloride must be reagent grade or Morton Culinox 999 Food grade. Fill the container marked "GMW15264 Solution Prep Container" to the fill line with food grade sodium chloride twice and empty into the 200 L tank. Add 5.7 kg of Fireclay. Fill the container marked "GMW15264 Solution Prep Container" to the fill line once with Fireclay and empty into the 200 L tank.

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 parts by weight of sodium chloride in 97 parts of reverse osmosis water to achieve a 3% by weight sodium chloride solution per specification ASTM D1193, Type IV. Sodium Chloride must be reagent grade or Morton Culinox 999 Food grade. Second, add 38 g of Fireclay to each liter of salt solution from the first step. Instructions and some example batch mixture formulae are shown in Appendix B, Table B1. Sources of Fireclay are listed in Appendix C. The salt concentration in the solution shall be checked at 20% intervals and maintained at 3% ± 1.0%. 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.

4.1.2 Coupon Preparation. Corrosion coupons should be cleaned with ethanol or acetone solution and accurately weighed prior to use. A two-step process using first ethanol then acetone is acceptable. The weight, in grams (g), shall be recorded and retained for future reference. If coupons are not used immediately, they should be stored such that they are corrosion free at the start of test.

It is critical that all forming or preservation oils/lubes be removed prior to exposure to allow for general/uniform corrosion of the coupon. This process can be aided by using a commercial grade degreaser or white spirits prior to ethanol or acetone clean.

4.1.3 Coupon Rack Preparation. Prior to start of test; prepare a coupon rack with sufficient coupons to monitor the test. Sufficient coupons should be enough to allow at least two coupons to be removed after each 10% interval of exposure, as listed in Appendix A, Figure A6.

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 test samples being tested, such that the coupons receive the same environmental exposure as the test samples.

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 wet/dry cycle:

4.3.1 First the test chamber temperature is set to 64 °C and the vent is closed. Then a minimum of 90 s corrosion solution spray is performed. Followed by one half of dynamic simulation loading per segment should be applied to the subject component or assembly at the beginning of each segment. After the 90 s spray, the vent is opened for 88.5 minutes to dry parts. Dynamic simulation may continue into the drying step. After 90 minutes, the second half of dynamic simulation loading commences and the vent is closed.

4.3.2 The time histories of the vent, spray, temperature, and an example dynamic simulation are shown in Appendix A, Figure A4. A Flow Diagram for the steps that comprise the test method is shown in Appendix A, Figure A5. Repeat the daily cycle as necessary.

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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.

Note: If dynamic simulation is requested, it shall be conducted simultaneously with the corrosion schedule. Examples of some general dynamic simulation test procedures are GMW14794 Suspension Multi-Axial, and GMW14868 Powertrain Mounting System: Inertia-Reacted, Real-Time Structural Durability. The standard for the component being tested must be supplied with the test request from customer if requested.

4.3.4 Test samples must be placed in the chamber in a manner that insures they all receive an equal and representative quantity of test solution during the spray portion of the cycle. They must also be oriented to avoid shielding other samples or trapping unrealistic quantities of test solution. Any test component actuation must be done in such a way that it accurately reproduced operation in the hands of the customer.

4.4 Test Environment Monitoring. Corrosion coupons shall be removed and analyzed at 10% intervals throughout the test to monitor the corrosion. To analyze coupons, remove one coupon from each end of the coupon rack, clean per 4.4.1 below to prepare for weighing, and calculate an average mass loss determination.

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 formula:

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

4.4.2 Coupon Mass Loss. The targeted mass loss at the 100% end of test is 9.5 g ± 2.38 g. The test is designed to achieve required mass loss in 100 cycles ± 24 cycles, or 50 days ± 12 days. When the option to run the test to 150% is employed, the coupon mass loss should be 17.25 g ± 4.31 g, and achieve the required mass loss in 75 days ± 18 days of test.

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

4.5 Inspection. The test sample(s) shall be inspected for fatigue cracks and for corrosion, and photographed (as necessary) at the end of predetermined number of cycles. If test samples containing plastic materials are being tested, any discoloration or degradation and/or adhesive bond failure (delamination) shall be noted and recorded.

If scribing is required, on either test samples, follow the methods described in GMW15282. This method also includes measurement of corrosion creepback from a scribe line and describes how to evaluate corrosion formation in unscribed areas. These methods should be used when reporting test results unless stated otherwise on drawings or agreed upon by test requestor and tester.

4.6 End of Test. At the end of test, the samples shall 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).

5.1.2 Calculate mass loss (reference 4.4.2).

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, Subsystem Technical Specifications, Component Technical Specifications, and Part Drawings.

5.3 Test Documentation.

5.3.1 Coupons. Coupon mass loss values are to be recorded after each 10% interval and at the completion of the desired test exposures. Data may be plotted and used to evaluate conformance to mass loss requirements using charts like the examples found in Appendix A, Figure A6.

5.3.2 Test Samples. Test reports should 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

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