



Cyclic Corrosion Laboratory 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 procedure describes an accelerated laboratory corrosion test method to evaluate assemblies and components. The test procedure provides a combination of cyclic conditions (salt solution, various temperatures, humidity, and ambient environment) to accelerate metallic corrosion. The procedure is effective for evaluating a variety of corrosion mechanisms, such as general, galvanic, crevice, etc. The test exposure/conditions can be individually tailored to achieve any desired level of corrosion exposure.

Also, synergistic effects due to temperature, mechanical and electrical cycling, along with other stresses, can be comprehended by this test. See Deviations Section at the end of this document for typical modifications.

1.2 Applicability. This is a cyclic corrosion test (refer to Appendix A, Figure A1) used for validation testing (cosmetic and/or functional/general durability), development testing, and quality control testing, for all global environmental regions.

The basic exposures for cosmetic corrosion are found as follows in exposures 0, A, B, and C. Exposures D and E are used for functional assessment (refer to Appendix A, Table A1, Table A2 and Table A3). All corrosion mechanisms are accelerated at different rates on test. Completing the test may not ensure that a component passes the functional requirement. A comprehensive failure mode analysis must be conducted to ensure all failure modes are considered and life expectancy is met.

- Exposure 0: All Areas (0 Year/Initial Delivery (ID)).
- Exposure A: Underbody (UB) Components.
- Exposure B: Underhood (UH) Components.
- Exposure C: Exterior (EXT) Components/Panels, Secondary Surfaces (SS), and Interior (INT) Components.
- Exposure D/E: All Components (Functional).

Note: For Exposure 0 (0 Year/ID) evaluate parts at two (2) cycles of the defined exposure linked to the associated vehicle area and mounting location as defined in Appendix A, Table A1 for Method 1, Table A2 for Method 2 and Table A3 for Method 3.

Note: Reference the Deviations Section (at the end of this GMW) for optional modifications.

1.3 Remarks. The test method is comprised of 1% (approximate) complex salt mist applications coupled with high temperature and high humidity and high temperature dry off. One (1) test cycle is equal to 24 h.

A cycle is made up of the daily events or test inputs illustrated in Appendix A, Figure A1. A cycle normally requires one (1) day to complete. The test exposure is dictated by a targeted coupon mass loss. A target range for the number of cycles necessary to meet the required mass loss is provided in Appendix A, Table A1 for Method 1, Table A2 for Method 2 and Table A3 for Method 3. The coupon mass loss values are used to verify that the correct amount of corrosion has been produced by the test. In addition to meeting mass loss requirements, the test must be conducted such that the number of cycles required to meet coupon mass loss requirements falls within the specified range.

2 References

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

2.1 External Standards/Specifications.

ASTM D610	ISO 6270-2	ISO 12103-1	SAE 2001-01-0640
ASTM D1193	ISO 8407	SAE 1008-1010	SAE J2329

2.2 GM Standards/Specifications.

GMW14700	GMW15356	GMW15358	GMW15359
GMW15282	GMW15357		

2.3 Additional References.

- ACT Test Panels, see Appendix A, visit <https://acttestpanels.com>
- Auto Technology Company, see Appendix A, visit <https://shop.autotechnology.net>
- National Exposure Testing, see Appendix A, visit www.nationalexposuretesting.com
- Powder Technology Incorporated, see Appendix A, visit www.powdertechinc.com

3 Resources

3.1 Facilities. Laboratory (preferably with controlled ambient conditions).

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 Ambient Stage. The apparatus for the ambient stage shall have the ability to maintain the following environmental conditions:

- Temperature: $(25 \pm 3)^\circ\text{C}$.
- Humidity: $(45 \pm 10)\%$ Relative Humidity (RH).
- Duration: Approximately 8 h per cycle.

3.2.2 Humid Stage. The apparatus for the humid stage shall have the ability to ramp to (within 1 h) and maintain (for approximately 7 h) under the following environmental conditions:

- Temperature: $(49 \pm 2)^\circ\text{C}$.
- Humidity: Approximately 100% RH.
- Duration: Approximately 8 h per cycle.

The apparatus shall consist of a fog/environmental chamber, suitable water supply conforming to ASTM D1193, Type IV, provisions for heating the chamber, and the necessary means of control.

3.2.2.1 Water Fog. The apparatus shall include provisions for a supply of suitably conditioned compressed air and one or more nozzles for fog generation. The nozzle(s) used for the generation of the fog shall be directed or baffled to minimize any direct impingement on the test samples.

At least two (2) clean fog collectors shall be placed within the exposure zone so that no drops of solution from the test specimens or any other runoff source shall be collected. The collectors shall be placed in the proximity of the test specimens, one nearest to any nozzle and the other farthest from all nozzles. Collection rates for each 80 cm² of horizontal collection area should be in the range of 0.75 mL/h to 1.5 mL/h (on average) for water that is collected in the collectors within the Humid Stage. Fog collection rates may be adjusted within this range as necessary to meet mass loss target rates.

Suitable collecting devices include glass or plastic funnels with the stems inserted through stoppers into graduated cylinders. Funnels with a diameter of 10 cm have an area of about 80 cm². Where samples cannot be read immediately upon completion of the humid stage, closed cell foam balls can be used in combination with the collection funnels (i.e., foam ball in mouth of funnel) to allow moisture to collect while minimizing evaporation.

3.2.2.2 Wet-Bottom. The apparatus shall consist of the chamber design as defined in ISO 6270-2. During wet bottom generated humidity cycles, the tester must ensure that visible water droplets are found on the samples to verify proper wetness.

3.2.2.3 Steam Generated Humidity. Steam generated humidity may be used provided the source of water used in generating the steam is free of corrosion inhibitors. During steam generated humidity cycles, the tester must ensure that visible water droplets are found on the samples to verify proper wetness.

3.2.3 Dry Off Stage. The apparatus for the dry off stage shall have the ability to ramp to (within 3 h) and maintain (for approximately 5 h) under the following environmental conditions:

- Temperature: $(60 \pm 2) ^\circ\text{C}$.
- Humidity: $\leq 30\% \text{ RH}$.
- Duration: Approximately 8 h per cycle.

The apparatus shall also have sufficient air circulation to prevent temperature stratification, and also allow thorough drying of the test samples.

3.2.4 Salt Mist Application. The solution shall be sprayed as an atomized mist and should be sufficient to rinse away any salt accumulation left from previous sprays. The test samples and coupons shall be thoroughly wet/dripping. Suitable application techniques include using a plastic bottle, or a siphon spray powered by oil free regulated air to spray the test samples and coupons.

Note: The force/impingement from this salt application should not remove corrosion or damage coatings/paints system of test samples.

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 $\times$ 50.8 mm long $\times$ 3.18 mm thick pieces of bare SAE 1008-1010 carbon steel, cold-rolled steel per SAE J2329, CR1E (see 7.2), uncoated, no post coating treatment, which are stamped with an alphanumeric identification number (reference Appendix A, Figure A2).

The coupons shall be secured to an aluminum or nonmetallic coupon rack with fasteners as shown in Appendix A, Figure A3 and Figure A4. The bolt, nut, and washers shall be made from a non-black plastic material, preferably nylon. Appendix A, Figure A4 shows a completed coupon rack configuration. The number of coupons recommended for different test durations are shown in Appendix A, Table A4.

3.3 Test Vehicle/Test Piece. The test sample (design, surface, and preparation) should be agreed to by the parties concerned (Design Engineer/Materials Engineer/Corrosion Engineer) and should simulate actual production materials and conditions when possible.

The number of test samples selected should be sufficient to ensure that the test results are statistically significant at some predetermined confidence level, unless otherwise specified. Any unusual observations made during sample preparation should be recorded and reported as part of the test results.

Where appropriate, test samples and/or control panels of known performance, should be tested concurrently. These controls can allow the normalization of test conditions during repeated running of the test (supplementing the required mass loss controls) and may also allow comparison of test results from different repeats of the test.

Where actual/representative production samples are available and the in-service orientation is known, test samples should be oriented to simulate these conditions.

When using test panels and/or the in-service orientation is not known, the sample shall, in principle, be oriented such that it is facing upward and at an angle of (20 ± 5) degrees from vertical.

3.3.1 Preconditioning of Test Samples. The gravelometer and/or a scribing tool can be used to provide damage to coating layers prior to testing in order to better represent potential in-service damage when appropriate. The use of either of these preconditioning methods shall be agreed upon by the parties concerned and shall conform to the methods described in GMW14700 and/or GMW15282.

3.4 Test Time. See cycle times in Appendix A, Table A1, Table A2 or Table A3.

3.5 Test Required Information. Not applicable.

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

4 Procedure

4.1 Preparation.

4.1.1 Salt Solution Preparation. The complex salt solution in percent (%) by mass shall be as specified as follows:

- Sodium Chloride (NaCl): 0.9%.
- Calcium Chloride (CaCl₂): 0.1%.
- Sodium Bicarbonate (NaHCO₃): 0.075%.

Sodium Chloride must be reagent grade or Morton Culinox 999 Food grade. Calcium Chloride must be reagent grade. Sodium Bicarbonate must be reagent grade (e.g., Arm and Hammer Baking Soda or comparable product is acceptable). Water (H₂O) must meet ASTM D1193, Type IV requirements.

Note: Either CaCl₂ or NaHCO₃ material must be dissolved separately in water and added to the solution of the other materials. If all solid materials are added dry, an insoluble precipitate may result.

Salt solution makeup calculator for the appropriate amount of NaCl, CaCl₂, NaHCO₃, and H₂O examples are shown in Appendix B, Figures B1 thru B6.

Additional contaminants (dust, grit, poultice, and exhaust condensate) called out in the Deviations Section are defined in Appendix C thru Appendix F.

4.1.2 Coupon Preparation. Corrosion coupons should be cleaned using a commercial grade degreaser solution and accurately weighed prior to use. The weight, 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 and/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 prior to methanol or acetone clean.

4.1.3 Coupon Rack Preparation. Prior to start of test; prepare the coupon rack with sufficient coupons to monitor the test. The number of coupons recommended for different test durations are shown in Appendix A, Table A4.

The exact location of each coupon on the rack shall be identified and recorded using the pre-stamped numbers for reference as illustrated in Appendix A, Figure A4.

Allow a minimum 5 mm spacing between the coupons and the rack surface. All coupons shall be secured vertically with no more than 15 degree deviation from vertical 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.

Note: Mass loss coupons are test monitoring devices and are not intended to be exposed to additional stresses which may be added to the base test (i.e., gravelometer, dust, grit, exhaust condensate, thermal exposure, etc.) Additional coupons may be required to monitor special test conditions (refer to Deviations Section).

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.

4.3.1 Test Execution. See Appendix A, Figure A1 for the steps that comprise the test method. Repeat the cycle daily, as necessary, until the test exposure requirements are met. At the option of the test requestor, the test can be continued throughout weekends to decrease the overall test time provided that the number of cycles and mass loss requirements are met.

4.3.2 Salt Application. For each salt mist application, use the spray apparatus to mist the samples and coupons until all areas are thoroughly wet/dripping. The quantity of spray applied should be sufficient to visibly rinse away salt accumulation left from previous sprays. The first salt mist application occurs at the beginning of the ambient stage. Each subsequent salt mist application, when specified, should occur approximately 1.5 h after the

previous application in order to allow adequate time for test samples to dry. A minimum of 1 h spacing between the end of a previous salt application and the subsequent salt application is required.

4.3.3 Test Options. The test may be modified to target specific component applications. Refer to Deviations Section.

4.3.4 Test Monitoring. Corrosion coupons shall be removed and analyzed after a predetermined number of cycles (typically five (5)) throughout the test to monitor the corrosion (less frequent for longer exposures, i.e., > 40 cycles). To analyze coupons, remove one (1) coupon from each end of the rack, clean to prepare for weighing, and an average mass loss determination. Although corrosion rate may vary somewhat during the duration of the test, an assumption of linearity may be useful in predicting the number of cycles to meet future mass loss targets.

4.3.4.1 Before weighing, clean the coupons using a mild sand/bead blast (550 ± 70) kPa ((80 ± 10) psi) 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:

$$\text{Mass Loss} = (\text{Initial Mass}) - (\text{End-of-Exposure Mass})$$

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

4.3.4.2 Compare the actual mass loss to the targeted value. Refer to Appendix A, Table A1, Table A2 or Table A3 for targeted mass loss values, in grams, for various test exposures as a function of the coupon's original thickness. Testing should be conducted as necessary to achieve necessary coupon mass loss. The number of cycles required to achieve required mass loss must meet that defined in Appendix A, Table A1 for Method 1, Table A2 for Method 2 and Table A3 for Method 3.

Note: Coupon mass loss targets corresponding to incremental test exposures are not included in Appendix A, Table A1, Table A2 or Table A3. The processes defined in 4.3.4 and 5.3.1 may be used to check test progress and assure that the test is being run correctly. Corrosion mass loss should increase consistently between documented exposure values. If the actual mass loss does not fall within the targeted range for the specified exposure(s) as listed in Appendix A, Table A1, Table A2 or Table A3, then the test should be repeated. Also, the reasons why the test did not fall within the target range should be investigated and corrected before resuming the test.

4.3.5 Test Acceleration. Temperature and humidity ramp times between the ambient stage and humid stage, and between the humid stage and dry stage, can have a significant effect on test acceleration. (Corrosion rates are highest during these transition periods.) Typically, the time from the ambient stage to the humid stage should be approximately 1 h and the transition time between humid stage and dry stage should be approximately 3 h. These ramp times can be adjusted to increase or decrease test acceleration in order to meet targeted mass loss. Any significant deviation from the ramp time described should be documented with the test results and requires prior approval by the parties concerned. Ramp time is to be included as part of the specified exposure period.

4.3.6 Extended Downtime. For any periods of extended downtime (i.e., > (4 to 5) d), it is recommended that test parts and associated coupons receive a freshwater rinse prior to the downtime period and are stored in ambient conditions to help minimize corrosive effects during this time. If downtime exceeds or is expected to exceed 17 consecutive days, this condition should be reviewed with test requestor. Additional special measures may be required to control the corrosion behavior of the test samples during this period. Storage in a desiccator, freezer, etc., may be appropriate. Extended downtime periods and any associated special measures should be included in the test documentation.

4.4 Cosmetic Corrosion Inspection. The test sample(s) shall be inspected for corrosion by means of GMW15356, GMW15357, GMW15358, GMW15359, and photographed (as necessary) at the end of predetermined cycles. Samples may be rated in terms of percent corroded area per ASTM D610 or some other comparable standard if agreed upon by test requestor and tester. 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 test samples, follow the method described in GMW15282. This method includes measurement of corrosion creepback from a scribe line. This method should be used when reporting test results unless stated otherwise on drawings or agreed upon by test requestor and tester.

4.5 End-of-Test (EOT) Functional Inspection. At EOT, the samples shall be rinsed with fresh tap water and allowed to dry before evaluating. EOT functional analysis may involve sectioning, microscopic analysis and/or removal of corrosion product to determine degree and extent of base metal attack.

5 Data

5.1 Calculations.

- Salt Solution: (varies, see Appendix B, Figures B1 thru B6).
- Coupon Mass Loss: (see 4.3.4.1).

5.2 Interpretation of Results. Acceptance criteria shall be specified within engineering documentation which may include: Material Specifications, Vehicle, Subsystem, Component Technical Specifications (VTS, SSTs, CTS), Statement of Requirements (SOR), Part Drawings, etc.

5.3 Test Documentation.

5.3.1 Coupons. Coupon mass loss values are to be recorded periodically throughout test and included as part of the overall test documentation in order to provide evidence of test control and adherence to specified test targets.

5.3.2 Test Reports. Test reports should include a description of the specific test cycle executed, description of test options or special instructions, test deviations and/or extended test downtime periods (including any special measures taken). Test reports should also include (at minimum) targeted and actual number of cycles run, as well as the targeted and actual coupon mass loss associated with the documented data collection points.

5.3.3 Test Equipment Documentation. The information in 5.3.3.1 thru 5.3.3.14 shall be recorded and available upon request for each cabinet/exposure location used to conduct test conditions as appropriate.

5.3.3.1 Cabinet Manufacturer/Model.

5.3.3.2 Humidity Profile.

5.3.3.3 Temperature Profile.

5.3.3.4 Humidification Process.

5.3.3.5 Collection Rate.

5.3.3.6 Dehumidification Process.

5.3.3.7 Heating Process.

5.3.3.8 Cooling Process.

5.3.3.9 Air Circulation Process.

5.3.3.10 Capacity.

5.3.3.11 Size.

5.3.3.12 Calibration Process.

5.3.3.13 Frequency of Calibration.

5.3.3.14 Ramp Time between Stages.

Cycle profiles (including typical steady state conditions and the ramp times between steady state conditions) should be maintained and available upon request.

Note: A form for Test Equipment documentation can be found in Appendix G, Data Sheet G1. If information does not change from test to test, documentation of a representative test will be acceptable. All the specified information will be required if test results are in question.

5.3.4 Test Solution. The information in 5.3.4.1 thru 5.3.4.5 shall be recorded and available upon request.

5.3.4.1 Frequency of Salt Solution Changes.

5.3.4.2 Method of Salt Application.

5.3.4.3 pH of Solution.

5.3.4.4 Salinity or Conductivity of Solution.**5.3.4.5** Solution Constituents.

Note: The form for Test Solution documentation can be found in Appendix H, Data Sheet H1. All specified information will be required if test results are in question.

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.

7 Notes**7.1 Glossary.**

pH of a Solution: The pH of a solution is a measure of hydrogen ion concentration, which in turn is a measure of its acidity.

7.2 Acronyms, Abbreviations, and Symbols.

°C	degrees Celsius
%	percent(age)
ASTM	ASTM International
CaCl ₂	Calcium Chloride
CTS	Component Technical Specification(s)
DMFC	Dry Milled Fire Clay
CR1E	Cold Rolled Grade 1 and Type E
EOT	End-of-Test
EXT	Exterior
g	gram(s)
gal	gallon(s)
GMNA	GM North America
GSSLT	Global Subsystem Leadership Team
h	hour(s)
H ₂ O	Water
ID	Initial Delivery (0 year)
INT	Interior
I/WS	Inside the Weather Strip
L	liter(s)
NaCl	Sodium Chloride
NaHCO ₃	Sodium Bicarbonate
ND	Not Defined
O/WS	Outside the Weather Strip
PS	Protected from Splash
RH	Relative Humidity
SOT	Start-of-Test
sp	Salt Spray(s)
SS	Secondary Surface

SSTS	Subsystem Technical Specification(s)
UB	Underbody
UH	Underhood
VTs	Vehicle Technical Specification(s)
w/w	weight by weight (or weight for weight)

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW14872, vehicle area including mounting location, Method, cosmetic and/or functional test Exposure, (0, A, B, C, D or E) or where the drawing or material specification calls for a specific deviation. This deviation should specify an associated mass loss.

Where:

ID	= Initial Delivery (0 year)
O/WS	= Outside the Weather Strip
PS	= Protected from Splash (see 7.1)
sp	= Salt Spray(s)
SS	= Secondary Surface
UB	= Underbody
UH	= Underhood

Example 1: For an UB component, pertaining to a global region specified as Method 3 cosmetic (including 0 year/ID, i.e., two (2) cycles).

Test to GMW14872, UB, All, 4 sp, Method 3, Exposures 0 and A.

Example 2: For a low, mid, or high UH component pertaining to a global region specified as Method 1 cosmetic and functional with splash protection not defined.

Test to GMW14872, UH, All, 4 sp, Method 1, Exposures B and E.

Example 3: For a mid-mounted and protected from splash UH component pertaining to a global region specified as Method 2 cosmetic and functional.

Test to GMW14872, UH, Mid PS, 1 sp, Method 2, Exposures B and E.

Example 4: For a door hinge mounted O/WS in a global region specified as Method 2 functional.

Test to GMW14872, SS O/WS, Method 2, Deviation Option 1, Exposure E.

In addition, the criteria for making pass/fail determinations must be specified (i.e., VTS Paragraph Number, etc.)

9 Release and Revisions

This standard was originated in November 2005. It was first approved by the Global Laboratory Corrosion Testing Harmonization Team in August 2006. It was first published in November 2006.

Issue	Publication Date	Description (Organization)
1	NOV 2006	Initial publication.
2	MAR 2010	Added Exposure 0: 0 year/ID to 1.2 and Table A1. Added Notes 1 to 3 to Figure A1. Updated 3.3 and added 3.3.1 Preconditioning of Test Samples. Moved 4.5 Test Monitoring to 4.3.4. Moved 4.4. Test Acceleration to 4.3.5. Added 4.3.6 Extended Downtime. Updated Underhood section of Table A1. Replaced Method SH/SM with Method 1/2 and Method SL with Method 3 in Table A1. Added additional source under Figure A4. Updated Deviations to include coupon exposure and mass loss. (Corrosion GSSLT - Global Subsystem Leadership Team)
3	MAR 2013	Addressed Internal audit issues around wet and dry time/duration. Added Exposure E. Updated Appendix A Table A1. Modified Notes 2 and 3. Added Table A2. Updated cinders provider. Replaced Appendix I with Appendix J; Appendix I (skipped). (Corrosion Global Subsystem Leadership Team)
4	OCT 2018	5 Year refresh. Updated 4.21; Section 6; Section 8 examples; Table A1 and A2 UH, High, Exposure B; Table A1, SS IW/S, Exposure C; deleted supplier for cinders in Table D1; added detail procedure for Appendix F; deleted note for Figure G2; option 1 edited number of sprays to refer to Table A1 or A2; deleted option 2; option 3 through 5 deleted number of cycles and minimum mass loss and added to refer to Table A1 or A2. (Materials – Corrosion GSSLT)
5	FEB 2021	Changed Methods 1/2 and 3 to Method 1, Method 2 and Method 3. Added Table A2 for Method 2. Revised Appendix G. Changed weekend environment in Appendix A to $\leq 35^{\circ}\text{C}$, $\leq 55\% \text{ RH}$. (Materials - Corrosion Engineering and Test GSSLT)