GM	WORLDWIDE ENGINEERING STANDARDS	Test Procedure Materials	GMW14872

Cyclic Corrosion Laboratory Test

1 Scope

Note: Nothing in the standard supersedes applicable laws and regulations unless specific exemption has been obtained.

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, which after the Appendices, for typical modifications.

1.2 Foreword. 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. 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.

1.3 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 (refer to GMW8738 for specific Method and applicable region).

The basic exposures for cosmetic corrosion are found below in exposures A through C. Exposure D is used for functional assessment (refer to Appendix A, Table A1). 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 A: Underbody Components

Exposure B: Underhood Components

Exposure C: Exterior Components/Panels, Secondary Surfaces, and Interior Components

Exposure D: All Components (Functional)

Note: Reference the Deviations section of this document for optional modifications.

2 References

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

2.1 External Standards/Specifications.

ASTM D610	ISO 8407
ASTM D1193	ISO 12103-1
ISO 6270-2	SAE J2329

2.2 GM Standards/Specifications.

GMW8738	GMW15357
GMW14700	GMW15358
GMW15282	GMW15359
GMW15356	

2.3 Additional References.

SAE 2001-01-0640

3 Resources

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

3.2 Equipment.

3.2.1 Ambient Stage. The apparatus for the ambient stage shall have the ability to maintain the following environmental conditions and per Appendix A, Figure A1:

- Temperature: 25 ± 3°C
- Humidity: 45 ± 10% RH

3.2.2 Humid Stage. The apparatus for the humid stage shall have the ability to maintain the following environmental conditions and per Appendix A, Figure A1:

- Temperature: 49 ± 2°C
- Humidity: ~100% RH

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 or nozzles used for the generation of the fog shall be directed or baffled to minimize any direct impingement on the test samples.

At least 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 cm^2 of horizontal collection area should be in the range of 0.75 to 1.5 mL/h (on average) of water will be collected in each collector over a minimum duration of 16 h. 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 cm^2. Where samples cannot be read immediately upon completion of the humid stage, closed cell foam balls can be used in combination with the collections 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 insure 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 insure 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 obtain and maintain the following environmental conditions:

- Temperature: 60 ± 2°C
- Humidity: ≤ 30% RH

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 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 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 A2.

3.3 Test Vehicle/Test Piece. Test samples shall be representative of production intent. Sample size shall be consistent with durability requirements determined by the appropriate Material / Corrosion Engineering department.

3.4 Test Time.

Calendar time:	See Appendix A, Table A1
Test hours:	See Appendix A, Table A1
Coordination hours:	See Appendix A, Table A1

4 Procedure

4.1 Preparation.

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

- Sodium Chloride (NaCl): 0.9%
- Calcium Chloride ($CaCl_2$): 0.1%
- Sodium Bicarbonate ($NaHCO_3$): 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 & Hammer Baking Soda or comparable product is acceptable). Water must meet ASTM D1193 Type IV requirements.

Note: Either $CaCl_2$ or $NaHCO_3$ 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 sodium chloride, calcium chloride, sodium bicarbonate, and water examples are shown in Appendix B, Figures B1 through B3.

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

4.1.2 Coupon Preparation. Corrosion coupons should be cleaned with methanol or acetone 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 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 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 A2.

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: Coupons are test monitoring devices and should not be exposed to additional stresses which may be added to the base test (i.e., gravelometer, dust, grit, exhaust condensate, thermal exposure, etc.)

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.2 Test Conditions. Deviations from the requirements of the procedure shall have been agreed upon by test requestor. Such requirements shall be specified on part drawings, test certificates, reports, etc.

4.3 Instructions. See Appendix A, Figure A1 (Flow Diagram) 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 requester, the test can be continued throughout weekends to decrease the over all test time provided that the number of cycles and mass loss requirements are met.

4.3.1 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 should occur approximately an hour and a half after the previous application in order to allow adequate time for test samples to dry.

Note: If gravelometer exposure is required, test samples (not coupons) may be exposed to gravelometer testing per GMW14700 before or during test exposure.

4.4 Test Acceleration. Humidity ramp times between the ambient and wet condition and between the wet and dry conditions can have a significant effect on test acceleration (this is because corrosion rates are highest during these transition periods). Typically, the time from ambient to the wet condition should be approximately 1 h and the transition time between wet and dry conditions should be approximately 3 h. These ramp times can be adjusted to increase or decrease test acceleration in order to meet targeted mass loss. Test acceleration can be optimized and tracked by using standard corrosion coupons as monitoring devices. Ramp time is to be included as part of the specified exposure period.

4.5 Test Monitoring. Corrosion coupons shall be removed and analyzed after a predetermined number of cycles (typically 5) throughout the test to monitor the corrosion (less frequent for longer exposures that is >40 cycles). To analyze coupons remove 1 coupon from each end of the rack, clean to prepare for weighing, and an average mass loss determination.

4.5.1 Before weighing, clean the coupons using a mild sand/bead blast (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:

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

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

4.5.2 Compare the actual mass loss to the targeted value. Refer to Appendix A, Table A1 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.

Coupon mass loss targets corresponding to incremental test exposures are not included in Appendix A, Table A1. The processes defined in section 4.5 “Test Monitoring” and section 5.3.1 “Coupons” 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 Table A1 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.

4.6 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 % 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.

4.7 End-of-Test Functional Inspection. At the end of test the samples shall be rinsed with fresh tap water and allowed to dry before evaluating. End-of-test 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 (reference Appendix B).
- Coupon mass loss (reference section 4.5.1 under 4.5 “Test Monitoring”).

5.2 Interpretation of Results. Acceptance criteria shall be specified within engineering documentation which includes: Material Specifications, Subsytem 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 set of a predetermined number of cycles (typically 5) 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 G, Figure G1 and Figure G2.

5.3.2 Test Samples. Test reports should include 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 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 De-humidification 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

If a recorder is in use, cycle profiles should be submitted with test sample data. If a recorder is not in use, written documentation should be provided indicating typical steady state conditions and the ramp times between steady state conditions.

Note: Form for Test Equipment documentation can be found in Appendix H. 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 following information 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 I. All specified information will be required if test results are in question.

6 Safety

This procedure may involve hazardous materials, operations, and equipment. This method does not propose to address all the safety problems associated with its use. It is the responsibility of the user of the method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary. Not Applicable.

7.2 Acronyms, Abbreviations, and Symbols.

EXT	Exterior
H/PDS	High & protected from direct splash
INT	Interior
I/WS	Inside the weather strip
O/WS	Outside the weather strip
s	Salt sprays
SH	Severe – High
SL	Severe – Low
SM	Severe – Moderate
SS	Secondary Surface
UB	Underbody
UH	Underhood

8 Coding System

This test procedure shall be referenced in other documents, drawings, VTS, CTS, etc. as follows:

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

Example 1: For an underbody component pertaining to a global region specified in Method SL cosmetic and functional

Test to GMW14872, UB, All, 4s, Method SL, Exposures A & D

Example 2: For a low, mid, or high underhood component pertaining to a global region specified in Method SH/SM cosmetic and functional

Test to GMW14872, UH, All, 4s, Method SH/SM, Exposures B & D

Example 3: For a high mounted and protected from direct splash underhood component pertaining to a global region specified in Method SL cosmetic and functional

Test to GMW14872, UH, High P/DS, 1s, Method SL, Exposures B & D.

Example 4: For a door hinge mounted outside the weatherstrip in a global region specified in Method SL cosmetic and functional.

Test to GMW14872, SS O/S, Method SL, Deviation Option #1, Duration 70 cycles.

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

9 Release and Revisions

9.1 Release. This standard originated in November 2005, replacing GM9540P. It was approved by the Global Laboratory Corrosion Testing Harmonization Team in August 2006. It was first published in November 2006.

Appendix A

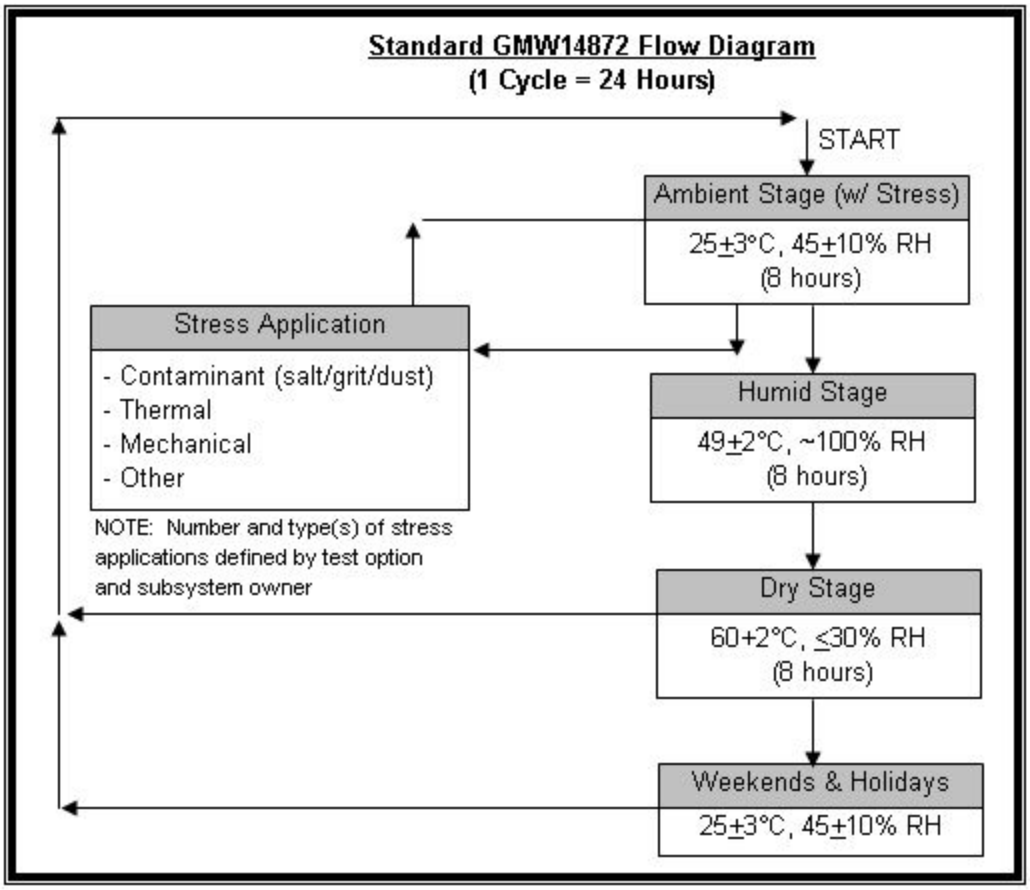


Figure A1: GMW14872 Flow Diagram

Table A1: GMW14872 Mass Loss Targets (3.18 mm thick coupons) – Cosmetic and Functional

Vehicle Area	Mounting Location of Component	Number of Salt Sprays	Method[Note 1]	Test Exposure	
				Cosmetic Mass Loss (Penetration[Note 2]) Requirements[Note 3], and # of Test Cycles	**Functional** Mass Loss Requirements[Note 3,4] and # of Test Cycles
Underbody (UB)	All	4 per cycle	Method SH/SM	Exposure A 0.84 ± 0.14 grams (38 ± 6 μm) 6 ± 1 cycles	Exposure D 9.47 ± 0.38 grams (430 ± 17 μm) 68 ± 7 cycles
			Method SL	Exposure A 0.42 ± 0.07 grams (19 ± 3 μm) 3 ± 1 cycles	Exposure D 4.74 ± 0.19 grams (215 ± 9 μm) 34 ± 4 cycles
Underhood (UH)	All	4 per cycle	Method SH/SM	Exposure B 1.32 ± 0.13 grams (60 ± 6 μm) 9 ± 1 cycles	Exposure D 7.11 ± 0.28 grams (323 ± 13 μm) 51 ± 6 cycles
			Method SL	Exposure B 0.66 ± 0.07 grams (30 ± 3 μm) 5 ± 1 cycles	Exposure D 3.55 ± 0.14 grams (161 ± 6 μm) 25 ± 3 cycles
	High & Protected from Direct Splash	1 per cycle	Method SH/SM	Exposure B 0.88 ± 0.09 grams (40 ± 4 μm) 11 ± 2 cycles	Exposure D 4.74 ± 0.19 grams (215 ± 8 μm) 59 ± 6 cycles
			Method SL	Exposure B 0.44 ± 0.04 grams (20 ± 2 μm) 6 ± 1 cycles	Exposure D 2.38 ± 0.10 grams (108 ± 4 μm) 30 ± 3 cycles
Exterior (EXT)	All	4 per cycle	Method SH/SM/SL	Exposure C 3.94 ± 0.28 grams (179 ± 13 μm) 28 ± 3 cycles	Exposure D 7.23 ± 0.29 grams (328 ± 13 μm) 52 ± 6 cycles
Secondary Surface (SS)	Outside the Weather Strip	1 per cycle	Method SH/SM/SL	Exposure C 1.98 ± 0.14 grams (90 ± 6 μm) 25 ± 3 cycles	Exposure D 3.61 ± 0.14 grams (164 ± 7 μm) 45 ± 5 cycles
	Inside the Weather Strip	1 per 5 cycles[5]	Method SH/SM/SL	Exposure C 0.40 ± 0.03 grams (18 ± 1 μm) 7 ± 1 cycles	Exposure D 0.73 ± 0.03 grams (33 ± 1 μm) 12 ± 2 cycles
Interior (INT)	Low	1 per 5 cycles[Note 5]	Method SH/SM/SL	Exposure C 1.30 ± 0.09 grams (59 ± 4 μm) 22 ± 3 cycles	Exposure D 2.38 ± 0.10 grams (108 ± 4 μm) 40 ± 4 cycles
	Mid, High	1 per 5 cycles[Note 5]	Method SH/SM/SL	Exposure C 0.40 ± 0.03 grams (18 ± 1 μm) 7 ± 1 cycles	Exposure D 0.73 ± 0.03 grams (33 ± 1 μm) 12 ± 2 cycles

Note 1: Refer to GMW8738 for applicable linkage of global region to test Method SH, SM or SL.
Note 2: Penetration factor used was 45.4. Refer to GMW8738 for actual calculation
Note 3: In addition to mass loss requirements, the test must be conducted such that the number of cycles falls within the specified range.
Note 4: Exposure D is used for functional assessment. 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.
Note 5: Number of salt sprays for 1 per 5 cycles should be sprayed at the start-of-test and every 5 cycles there after.

Table A2: Number of Coupons Recommended

Number of Required Cycles	Number of Coupons	Removal Frequency
≤ 10 cycles	6	5 Cycles
11 to 20 cycles	10	5 Cycles
21 to 30 cycles	14	5 Cycles
31 to 40 cycles	18	5 Cycles
41 to 80 cycles	18[Note 1]	10 Cycles

Note 1: Additional coupons may be required if earlier evaluations must be conducted.

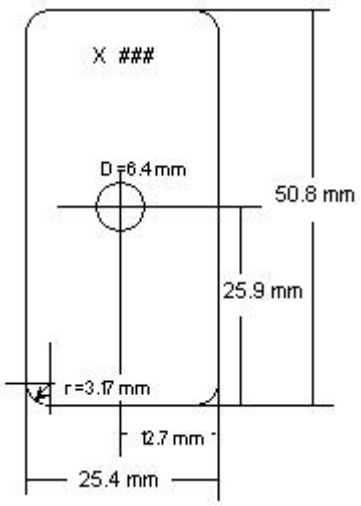
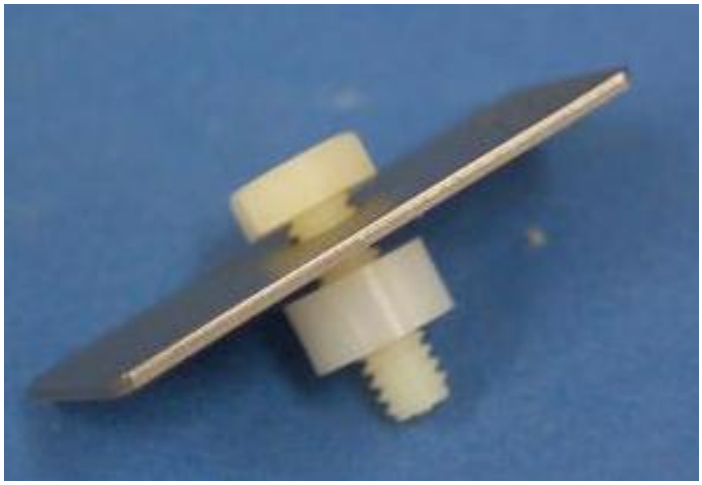


Figure A2: Coupon Schematic



Nylon bolts and washers suitable are as follows:

Bolt: 0.6 to 50.8 cm x 1.5 cm (¼ to 20 in x ½ in) hex head cap screw, solid nylon

0.6 to 50.8 cm x 1.27 cm (¼ to 20 in x 3/7 in) hex head cap screw, solid nylon

Washer: 1.5 cm x .65 cm x 0.5 cm (½ in x 0.257 in x 0.197 in) thick flat washers

Nut: 0.6 to 50.8 cm (¼ to 20 in) nut, solid nylon

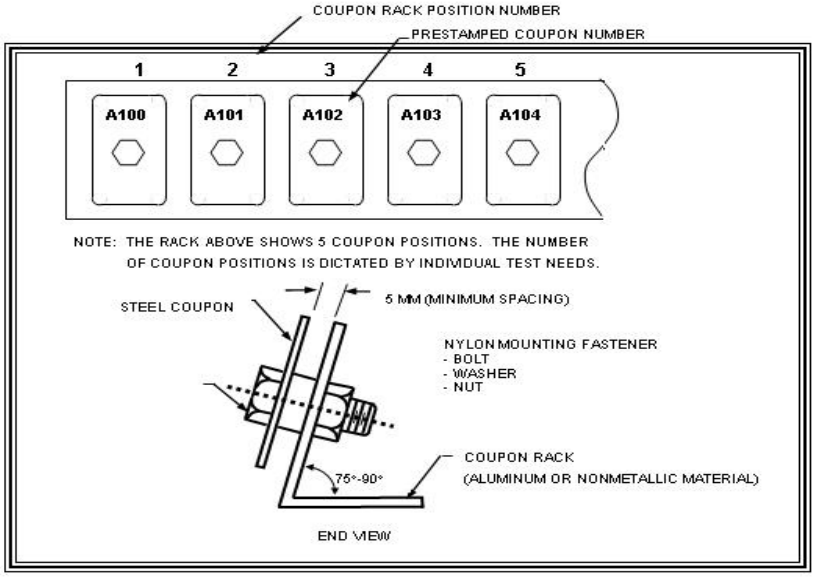


Figure A4: Coupon Bracket Assembly Illustration

Suitable coupons and/or coupon rack assemblies can be purchased from the following:

ACT Test Panels
273 Industrial Drive
P.O. Box 735
Hillsdale, Michigan 49242
(517) 439-1485

National Exposure Testing
3545 Silica Road
Suite E
Sylvania, Ohio 43560
(419) 841-1065

Appendix B

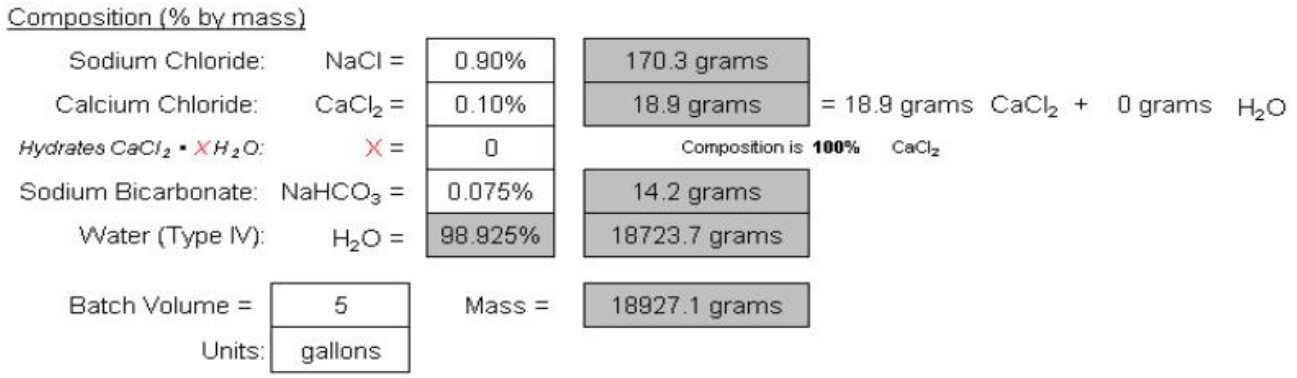


Figure B1: GMW14872 Salt Solution Calculator for Anhydrous (X=0) Calcium Chloride Based on a Five Gallon Batch Solution

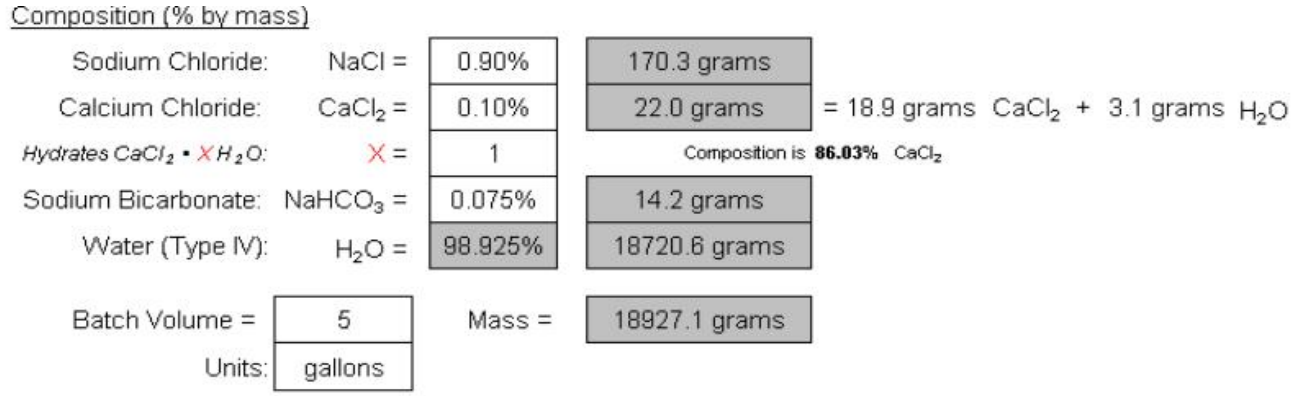


Figure B2: GMW14872 Salt Solution Calculator for One Hydrate (X=1) Calcium Chloride Based on a Five Gallon Batch Solution

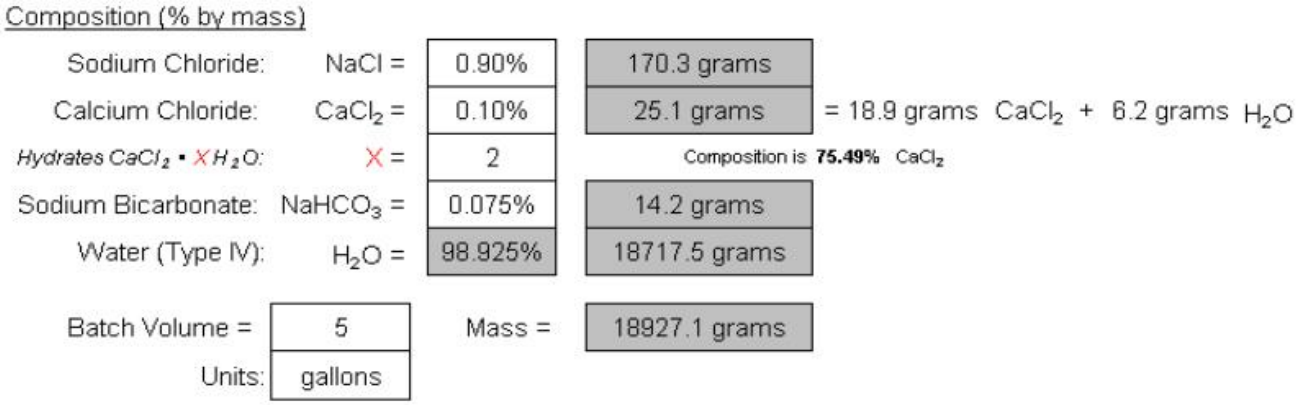


Figure B3: GMW14872 Salt Solution Calculator for Dihydrate (X=2) Calcium Chloride Based on a Five Gallon Batch Solution

Note: An electronic copy can be obtained upon request, please contact GMNA Corrosion Engineering.

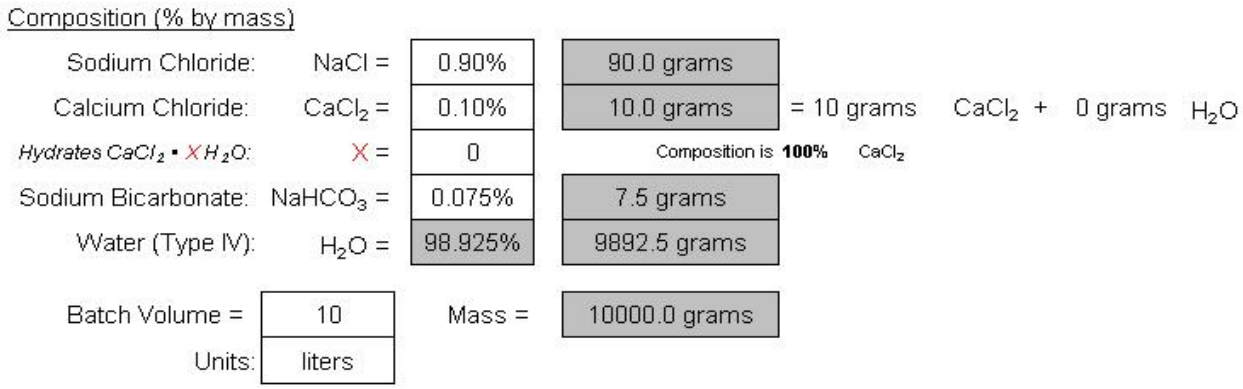


Figure B4: GMW14872 Salt Solution Calculator for Anhydrous (X=0) Calcium Chloride Based on a Ten Liter Batch Solution

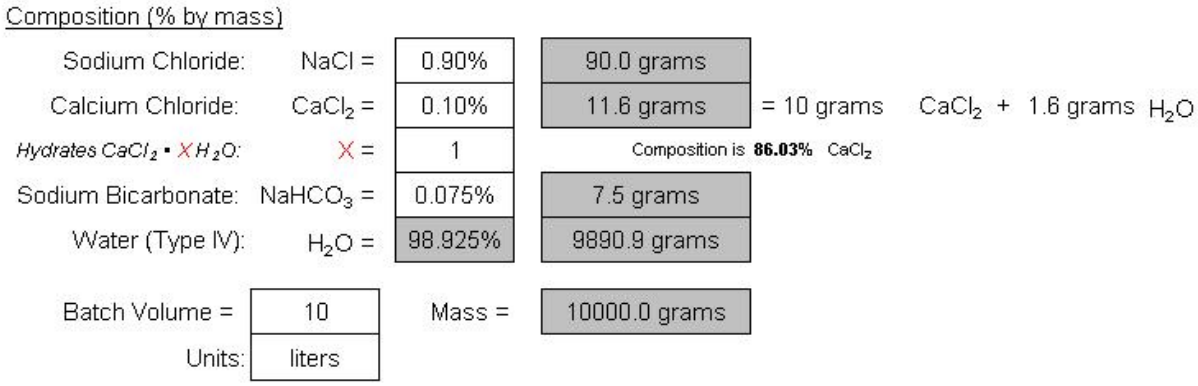


Figure B5: GMW14872 Salt Solution Calculator for One Hydrate (X=1) Calcium Chloride Based on a Ten Liter Batch Solution

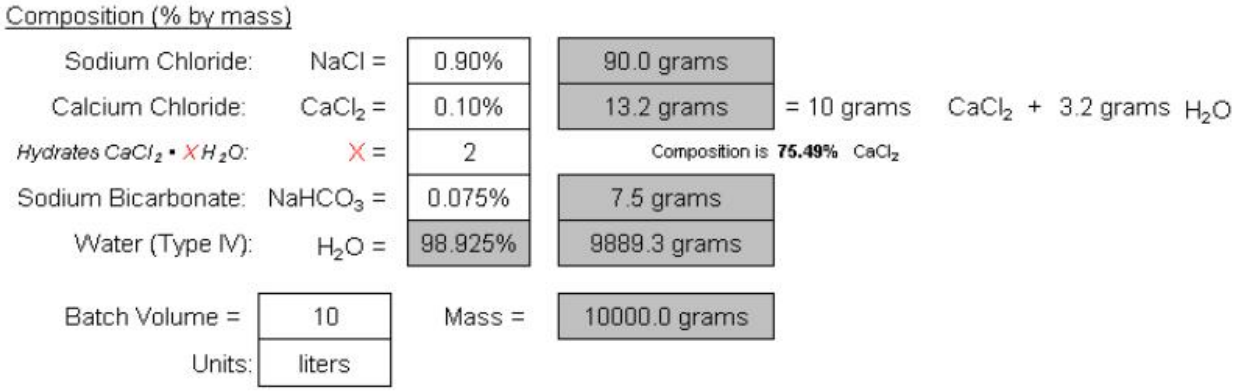


Figure B6. GMW14872 Salt Solution Calculator for Dihydrate (X=2) Calcium Chloride Based on a Ten Liter Batch Solution

Note: An electronic copy can be obtained upon request, please contact GMNA Corrosion Engineering.

Appendix C

Dust Type

Arizona Dust conforming to ISO 12103-1, A2 Fine, procured from Powder Technology Incorporated of Burnsville, Minnesota.

Spray Apparatus

Modify a garden duster to accept an air line connection where the manual pump lever is located (remove the manual pump lever and attach a fitting to accept air line). Garden dusters with an 8 mm diameter hole for dust application. Garden dusters from the following manufactures could be modified: Hudson Sprayer, Hudson Manufacturing Company, Chicago Illinois or R.L. Corporation, Lowell, Michigan (a division of Root-Lowell Manufacturing).

Dust Application

Using 25 to 30 psi of air line pressure apply a dust mist such that a semi-transparent layer is applied to the entire part or focal area of the part. Keep the applicator agitated to ensure proper dust application (agitate/shake duster between applications).

Appendix D

Grit Specification

Grit Trough Solution Mix (typical recipe to be mixed with 5 gallons of water – total solution amount can be increased or decreased by multiplying or dividing as necessary)

Solid Contaminants: **(Grit solution constituents may be purchased from ACT Test Panels)**

Fire Clay – 900 grams

Cinders – 900 grams

Sand – 900 grams

Ottawa Lakes Screening – 1080 grams

1% Complex Salt Mix: (Salts not included in shipment, can purchase through VWR Scientific)

NaCl (sodium chloride) – 170.37 grams

$CaCl_2 . 2H_20$ (calcium chloride dihydrate)***** – 25.07 grams (18.93 grams – anhydrous)

***Note:** It is permissible to use hydrated salts

$NaHCO_3$ (sodium bicarbonate) – 14.2 grams (baking soda is also suitable and can be purchased at a grocery store)

Mixing Instructions:

Add 5 gallons of distilled or deionized water per ASTM D1193 Type IV to the premix bag of solid ingredients (or if you do not have pre-mixed bags, weigh out the materials listed above, put them in a container able to hold at least 6 gallons and then add the water). Thoroughly mix liquid and solids together with moderate agitation. If spraying the solution, immediately after agitation or during agitation, siphon solution from the top half of the mix for use in spraying on test samples. An alternative method would be to build an automatic spray system incorporating a pumping device that either prescreened the coarse solids or drew liquid from the top half of the solution. In the case of a test where a part is to be submerged in the solution and then cycled/stroked, make sure that the part stays in the top $2/3^{rds}$ of the solution to avoid ingestion or damage due to large particles that fall out of solution and reside in the bottom of the mix.

Note: Be sure to pour/douse the grit solution on all areas of the part that would potentially experience splash in the field. Depending on number of samples, level of contamination, and exposure of test, it may be appropriate to collect and reuse grit solution. A fresh batch of grit solution should be made at minimum once a month for the duration of the test.

Table D1: Grit Trough Constituent Supplier Information

Constituent	Supplier	Address	Phone/Contact
Cinders	C&M Trucking Oerther Brothers	3500 N. Monroe Dr. Monroe, MI 48161	(313) 241-0766
Fireclay – 20 Mesh DMFC sacked	Harbison Walker	28777 Goddard Rd. Romulus, MI 48174	(734) 955-6025
Sand **–** unwashed play sand	Local hardware	MPG – Corrosion Eng.	(248) 685-6226
Ottawa Lakes Screening	Stoneco	10411 Darling Rd Milan, MI 48160	(734) 241-8966

Appendix E

Poultice Specification

Solid Contaminants: (Poultice solution constituents may be purchased from ACT Test Panels)

Fire Clay – 22.5% by weight

Sand – 72.5% by weight

Calcium Chloride – 5% of the combined Fire Clay and Sand weight

Mixing Instructions:

Combine fire clay and sand. Add 5% Calcium Chloride to the combined weight of the fire clay and sand. Next, distilled or deionized water per ASTM D1193 Type IV is added to the solid ingredients in small amounts until desired poultice consistency. Poultice is to be packed (approximately ¼ inch thick) on test specimens.

Example: (100 gram batch)

Mix 22.5 grams of fire clay and 72.5 grams of sand. Add 5 grams of Calcium Chloride to the fire clay and sand mixture. Thoroughly mix solid constituents together. Add small amounts of water at a time while thoroughly mixing liquid and solid constituents until it creates a thick and moist poultice consistency. Apply poultice to test specimen packing the poultice to approximately ¼ inch thick.

Appendix F

Table F1: Exhaust Condensate Specification (Reference SAE 2001-01-0640)

No.	Ingredients	Level (Wt. %)	Amount per 30 gallons
1	Activated Carbon	0.5%	5715.2 grams
2	Ammonia (as Ammonium Hydroxide, 29.7%)	0.25%	959.0 grams
3	Sulfate (as Ammonium Sulfate)	0.125%	195.2 grams
4	Acetate (as Ammonium Acetate)	0.04%	59.3 grams
5	Sulfite (as Ammonium Sulfite)	0.025%	47.5 grams
6	Formaldehyde (37%)	0.025%	76.7 grams
7	Nitrate (as Ammonium Nitrate)[Note 1]	0.012%	17.6 grams
8	Formic Acid (88%)	0.01%	13.2 grams
9	Chloride (as Ammonium Chloride)	0.005%	8.5 grams
10	Water	Balance	

Note: Total for nitrite and nitrate

Procedure:

Dissolve each of ingredients #2 to #9 in distilled water and add while stirring one by one to the prepared container. Add rest of water and #1 (activated carbon). Mix thoroughly. Keep in tightly closed container.

Appendix G

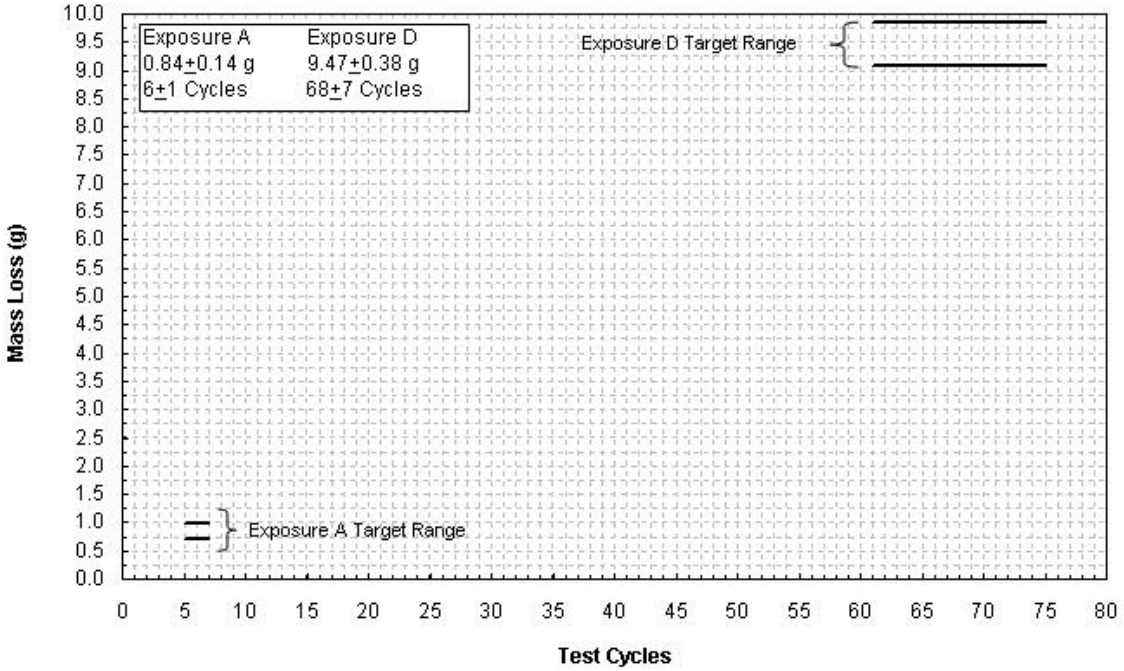


Figure G1: GMW14872 Underbody (UB) Mass Loss Target Chart for Method SH/SM

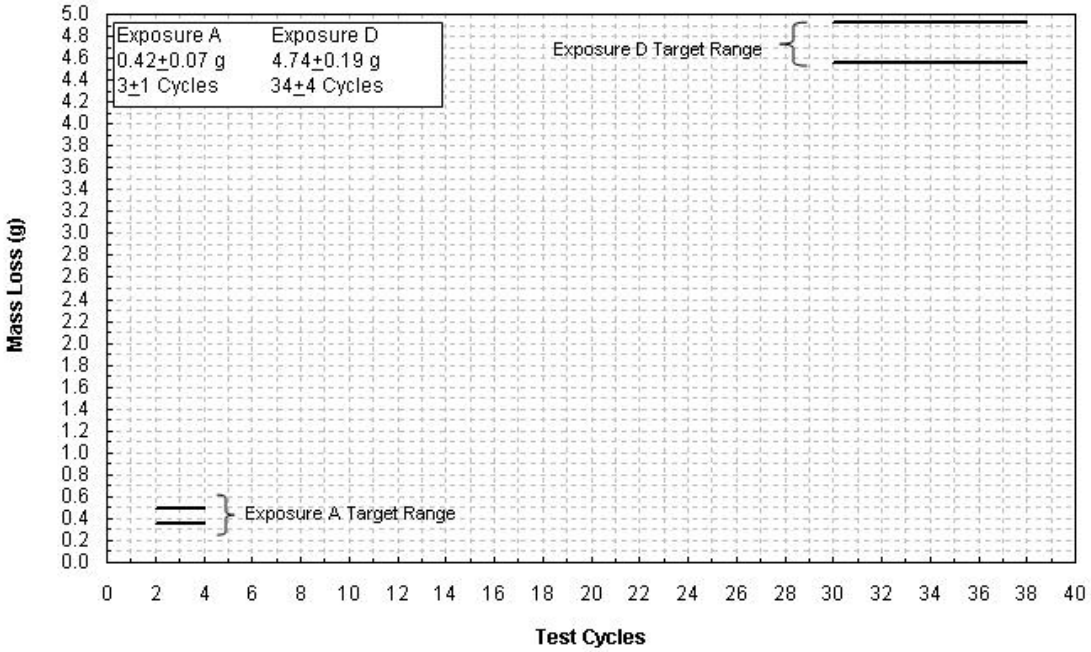


Figure G2: GMW14872 Underbody (UB) Mass Loss Target Chart for Method SL

Note: An electronic copy for both corrosion severities (i.e. Method SH/SM & Method SL) and of all the vehicle component areas (i.e., underbody, exterior, secondary surface, and interior) can be obtained upon request, please contact GMNA Corrosion Engineering.

Appendix H

Test Equipment Documentation Form

Project Number(s):	
Start-of-Test (Date):	End-of-Test (Date):

Operational Mode	Description of any test interruptions (fill in table below):	
	Date	Description of Test Interruption
	Operation (*Manual / Automatic): *Note: fill out information below	
	Average Temperature [Range] (°C):	
	Average Humidity [Range] (%RH):	
	☐	Chart or data (temperature and humidity) documenting at least 1 weekend [include date(s)]

Ambient Stage	Cabinet Manufacturer:	Cabinet Model:
	Cabinet Serial No.:	Air Movement (units):
	Cabinet Size:	Cabinet Capacity:
	Last Calibration (Date):	Next Calibration (Due Date):
	Average Temperature [Range] (°C):	
	Heating Process:	
	Cooling Process:	
	Average Humidity [Range] (%RH):	
	☐	Chart or data (temperature and humidity) documenting at least 1 cycle of this stage [include date(s)]

Test Equipment Documentation Form

Humidity Stage	Cabinet Manufacturer:	Cabinet Model:
	Cabinet Serial No.:	Air Movement (units):
	Last Calibration (Date):	Next Calibration (Due Date):
	Ramp Time (Ambient to Humidity Stage):	
	Average Temperature [Range] (°C):	
	Heating Process:	
	Average Humidity [Range] (%RH):	
	Humidification Process:	
	☐ Chart or data (temperature and humidity) documenting at least 1 cycle of this stage [include date(s)]	
	Collection Rate (fill in table):	

Sample Cycle	Actual Number of	Collection Rate (mL/hr/80 cm^2)	Date of Collection	Moisture Visible on Samples (Yes/No)

Dryoff Stage	Cabinet Manufacturer:	Cabinet Model:
	Cabinet Serial No.:	Air Movement (units):
	Cabinet Size:	Cabinet Capacity:
	Last Calibration (Date):	Next Calibration (Due Date):
	Ramp Time (Humidity to Dryoff Stage):	
	Average Temperature [Range] (°C):	
	Heating Process:	
	Average Humidity [Range] (%RH):	
	De-humidification Process:	
	☐ Chart or data (temperature and humidity) documenting at least 1 cycle of this stage [include date(s)]	

Appendix I

Test Solution Documentation Form

<table>
<tr><td rowspan="12">Test Solution</td><td colspan="7">Water Type (refer to ASTM D1193):</td></tr>
<tr><td colspan="7">Volume of Batch (gallons or liters):</td></tr>
<tr><td colspan="7">Sodium Chloride [NaCl] (grams):</td></tr>
<tr><td colspan="7">Sodium Bicarbonate [$NaHCO_3$] (grams):</td></tr>
<tr><td colspan="6">Calcium Chloride [$CaCl_2 \cdot X\ H_2O$] (grams):</td><td>X =</td></tr>
<tr><td colspan="7">Test Solution Monitoring (fill in table for each test solution batch):</td></tr>
<tr><td>Date of Initial Use</td><td>Initial pH</td><td>Initial Conductivity (µS @ 25°C)</td><td>Date of Last Use</td><td>Total Number of Test Cycles</td><td>Final pH</td><td>Final Conductivity (µS @ 25°C)</td></tr>
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<tr><td colspan="3">Spray Pressure (units):</td><td colspan="4">Spray Flow (units):</td></tr>
</table>

Deviations

The following procedure deviations are based on field knowledge combined with engineering judgment to enhance the test's ability to predict field performance. Prior to making additional modifications or to assist in determining the appropriateness of one of the following options, please contact GMNA Corrosion Engineering.

Deviations are generally made during the ambient stage to included additional test inputs such as dust applications, grit sprays, poultice applications, dynamic cycling, electrical cycling, thermal inputs, gravelometer, exhaust condensate spray, and acid rain spray.

Option 1: Dust Application & Fresh Water Rinse Addition

Modification to Ambient Stage:

1 salt spray per cycle

1 dust application every 5 cycles starting with the 1st cycle (dust should be applied immediately following the salt spray application) (refer to Appendix C for dust specification)

1 fresh water rinse applied and allowed to dry prior to the salt application on days when dust is applied

Applicable Components (dust and fresh water rinse):

Side Door Latches and Hood Latches (assume no weatherseal protection) [previously Option III]

Door Cavity Hardware [previously Option VIII]

Applicable Components (dust only)*:

Door Hinges, Hood Hinges, Fuel Filler Door Hardware, and Decklid Hinges (assume no weatherseal protection) [previously Option IV]

Door Detent (assume no weather seal protection) [previously Option VII]

Windshield wiper system [newly added]

Test duration to evaluate functional corrosion is 70 cycles.

Note: *When testing these components eliminate the fresh water rinse portion.

Option 2: A/C Compressor Addition [previously Option I]

Modifications to Ambient Stage:

1 salt spray on 1st cycle – compressor running

1 grit spray on 5th cycle – compressor static (refer to Appendix D for grit solution)

1.5 hours of compressor run time (cycling 12 seconds on and 3 seconds off)

Test duration to evaluate functional corrosion is 70 cycles.

Option 3: Key Cylinder Addition (previously Option V)

Modification to Ambient Stage:

1 hose salt spray per cycle (approximately 10 second application, ¾ to 1" hose, 6 gallons per minute supply)

1 dust application (both sides of test sample in fixture) every 5 cycles starting with the 1st cycle (dust should be applied immediately following the salt spray application) (refer to Appendix C for dust specification)

1 fresh water rinse applied and allowed to dry prior to the salt application on days when dust is applied

Test duration to evaluate functional corrosion is 70 cycles.

Option 4: Thermal Soak Addition

Modification to Ambient Stage: Oven Soak (# hours) followed by 25±3°C, 45±10%RH (# hours) 1st salt spray prior to oven soak with remaining 3 salt sprays spaced 1 hour apart

Applicable Components:

Transmission Oil Cooler Line: 121 ± 2°C (2 hours) [previously Option II]

Muffler and Tailpipe: 204 to 260°C (4 hours) [previously Option X]

Exhaust Manifold, Flex Coupling: 482 ± 2°C (4 hours) [previously Option IX]

Test duration to evaluate functional corrosion is 70 cycles.

Option 5: Exhaust Condensate Addition

Modification to Ambient Stage: by 25 ± 3°C, 45 ± 10% RH (8 hours)

3 salt spray per cycle spaced 1 ½ hours apart

1 exhaust condensate spray 1 ½ after last salt spray (refer to Appendix F Exhaust Condensate)

Applicable Components:

Rear Bumper, Exhaust Tip

Test duration to evaluate functional corrosion is 70 cycles.

Additional options can be customized to specific components or subsystems to increase the ability to conduct validation or development testing.

General guidelines defined in Appendix A, Table A1 may used as a building block for customizing a test. Prior to making additional modifications or to assist in determining the appropriateness of one of the following options, please contact GMNA Corrosion Engineering.