SAE International™ SURFACE VEHICLE STANDARD

SAE J2334

REV. OCT2002

Issued 1998-06
Revised 2002-10

Superseding J2334 JUN1998

Cosmetic Corrosion Lab Test

Foreword—This cosmetic corrosion lab test procedure is based on field correlated lab test procedure parameters as determined by a Design of Experiment process conducted by the SAE Automotive Corrosion and Prevention Committee (SAE/ACAP) and the Auto/Steel Partnership (A/SP) Corrosion Task Force. Results from this test will provide excellent correlation to severe corrosive field environments with respect to cosmetic corrosion performance. For historical information on the development of this test, refer to 2.1.4.

A typical automotive paint system was used to develop this test. See 2.1.4, 1 to 5. If a different type of coating system is used, field correlation must be determined.

1. Scope—The SAE J2334 lab test procedure should be used when determining cosmetic corrosion performance for a particular coating system, substrate, process, or design. Since it is a field correlated test, it can be used as a validation tool as well as a development tool. If corrosion mechanisms other than cosmetic or general corrosion are to be examined using this test, field correlation must be established.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1563—Guidelines for Laboratory Cyclic Corrosion Test Procedures for Painted Automotive Parts

2.1.2 ASTM Publications—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM D 1193—Specification for Reagent Water
ASTMD1654—Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 1735—Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
ASTM D 2247—Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM E 70-90—Test Method for pH of Aqueous Solutions with the Glass Electrode
ASTM G 1—Recommended Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens

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2.1.3 GENERAL MOTORS PUBLICATIONS—Available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112.

GM 9540P

2.1.4 OTHER PUBLICATIONS

1. Townsend, H. E., "Development of an Improved Laboratory Corrosion Test by the Automotive and Steel Industries," in Advanced Coatings Technology, Proceedings of the fourth Annual ESD Advanced Coatings Conference, The Engineering Society, Ann Arbor, MI, 1994, pp. 29-49.
2. Roudabush, L.A., Townsend, H.E., and McCune, D.C., "Update on the Development of an Improved Cosmetic Corrosion Test by the Automotive and Steel Industries," Automotive Corrosion and Prevention Conference Proceedings, P-268, Society of Automotive Engineers, Warrendale, PA, 1993, pp. 53-63.
3. Townsend, H.E., "Accelerated Corrosion Testing: A Cooperative Effort by the Automotive and Steel Industries, " Proceedings of the Symposium on Corrosion-Resistant Automotive Sheet Steels, ASM Materials Congress, ASM International, Metals Park, OH, 1988, pp. 55-67.
4. Townsend, H.E., "Status of a Cooperative Effort by the Automotive and Steel Industries to Develop a Standard Accelerated Corrosion Test," Automotive Corrosion and Prevention Conference Proceedings, P-228, Society of Automotive Engineers, Warrendale, PA, 1989, pp. 133-145.
5. Townsend, H.E., Granata, R.D., McCune, D.C., Schumacher, W.A., and Neville, R.J., "Progress by the Automotive and Steel Industries Toward an Improved Laboratory Cosmetic Corrosion Test," Automotive Corrosion and Prevention Conference Proceedings, P-250, Society of Automotive Engineers, Warrendale, PA, 1991, pp. 73-97.
6. Stephens, M.L., "SAE ACAP Division 3 Project: Evaluation of Corrosion Test Methods," Automotive Corrosion and Prevention Conference Proceedings, P-228, Society of Automotive Engineers, Warrendale, PA, 1989, pp. 157-164.
7. Lutze, F.W., and Shaffer, R.J., "Accelerated Atmospheric Corrosion Testing of AISI Panels," Automotive Corrosion and Prevention Conference Proceedings, P-250, Society of Automotive Engineers, Warrendale, PA, 1991, pp. 115-127.
8. Petschel, M., "Statistical Evaluation of Accelerated Corrosion Tests and Correlation with Two-Year On-Vehicle Tests," Automotive Corrosion and Prevention Conference Proceedings, P-250, Society of Automotive Engineers, Warrendale, PA, 1991, pp. 179-203.
9. Davidson, D.D. and Schumacher, W.A., "An Evaluation and Analysis of Commonly Used Accelerated Cosmetic Corrosion Tests Using Direct Comparison with Actual Field Exposure," Automotive Corrosion and Prevention Conference Proceedings, P-250, Society of Automotive Engineers, Warrendale, PA, 1991, pp. 205-219.
10. Ostermiller, M.R., and Townsend, H.E., "On-Vehicle Cosmetic Corrosion Testing of Coated and Cold-Rolled Steel Sheet," Automotive Corrosion and Prevention Conference Proceedings, P-268, Society of Automotive Engineers, Warrendale, PA, 1993, pp. 65-83.
11. Granata, R.D. and Moussavi-Madani, M., "Characterization of Corrosion Products and Corrosion Mechanisms on Automotive Coated Steels Subjected to Field and Laboratory Exposure Tests," Leigh University Report to the ASP Corrosion Task Force, January 10, 1996.
12. ASTM E 691-92, "Standard Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method."
13. ASTM E 177-90a, "Standard Practice for Use of the Terms Precision and Bias in ASTM Test Methods."
14. Townsend, H.E. and McCune D.C., "Round-Robin Evaluation of a New Standard Laboratory Test for Cosmetic Corrosion," Automotive Corrosion and Prevention Conference Proceedings, SP-1265, Society of Automotive Engineers, Warrendale ,PA, 1997, pp. 53-68.
15. H. E. Townsend, D. D. Davidson, and M. R. Ostermiller, "Development of Laboratory Corrosion Tests by the Automotive and Steel Industries of North America," Proceedings of the Fourth International Conference on Zinc and Zinc-Alloy Coated Steel Sheet, Iron and Steel Institute of Japan, Tokyo, pp. 659-666 (1998).

16. F. W. Lutze, D. C. McCune, and K. A. Smith, "Development of and Interlaboratory Test Evaluation of a Laboratory Corrosion Tests by the Automotive and Steel Industries of North America," 24th Annual Conference of Future Of Coatings Under Study (FOCUS), Detroit Society for Coatings Technology, Troy Michigan, U.S.A., (4-1999).
17. F. W. Lutze, D. C. McCune, H. E. Townsend, K. A. Smith, R. J. Shaffer, L. S. Thompson, and H. D. Hilton, "The Effects of Temperature and Salt Concentration on the Speed of the SAE J2334 Cyclic Corrosion Test," Proceedings of the European Corrosion Congress, London (2000).
18. F. W. Lutze, D. C. McCune, J. R. Schaffer, K. A. Smith, L.S. Thompson, and H. E. Townsend, "Interlaboratory Testing to Evaluate improvements in the precision of the SAE J2334 Cyclic Corrosion Test," Proceedings of the Fifth International Conference on Zinc and Zinc Alloy Coated Steel Sheet, Centre for Research in Metallurgy, Brussels Belgium (June 2001).

2.1.4.1 Reproducibility and Repeatability information concerning this test method is discussed in SAE Paper 970734. See Reference 14.

3. Definitions

3.1 Cosmetic Corrosion—Corrosion that occurs as a result of the breakdown or damage to a coating system. Typically, this type of corrosion does not impact function but does compromise appearance.

3.2 General Corrosion—Corrosion of a component that is typically bare (no organic coating). Corrosive attack is uniform in nature and distributed over "large" areas.

3.3 Scribe Creepback—Coating creepback resulting from corrosion and undercutting from the scribe line. A scribe is a controlled simulated damage site designed to represent a scratch or chip.

3.4 Corrosion Coupons—Samples of bare metals, that are used to monitor and compare the corrosivity of laboratory corrosion tests in terms of mass-loss.

3.5 Test Controls—Components (i.e., test panels, coupons, parts, etc.) which have been previously tested and/or correlated. They can be used to control the test conduct and compare the test results (also assist in evaluating reproducibility and repeatability).

4. Equipment and Test Materials

4.1 Test Cabinets—Test cabinet(s) with the ability to obtain and maintain the following environmental conditions (Reference SAE J1563, ASTM D 1735, and ASTM D 2247):

a. 50 °C ± 2 °C and 100% Relative Humidity—The 100% relative humidity wet-stage condition can be achieved by use of one of the three methods shown as follows. Whichever method is employed, test samples and controls are required to be visibly moist/wet.

1. Wet-bottom method according to ASTM D 2247 – except that the temperature shall be 50 °C ± 2 °C.
2. Water fog method according to ASTM D 1735, except that the collection rate is reduced from a range of 1.5 to 3 mL/h to 0.75 to 1.5 mL/h. The use of this method requires that the collection rates be documented.
3. Steam (vapor) generator method.

NOTE— The majority of the development of this specification was performed using the Wet-bottom method of humidity generation. This method was used as the basis when comparing other methods of humidity generation as well as other variables.

b. 60 °C ± 2 °C and 50% Relative Humidity ±5%. Additional equipment will be required to maintain the 50% relative humidity condition.

Air circulation must be sufficient to prevent temperature stratification and allow drying of test parts during the dry-off portion of the test cycle.

Air circulation can be obtained through the use of a fan or forced air.

4.2 Salt Solution Application—The samples must be subject to an application of salt solution by use of one of the three methods shown as follows. Whichever method is employed, test samples and controls are required to be visibly moist/wet during the entire 15-minute interval of each test cycle.

0.5% $NaCl$
0.1% $CaCl_2$
0.075% $NaHCO_3$

a. Immersion Method—Test specimens are to be immersed in the salt solution for a 15-minute interval of each test cycle.
b. Spray Method—A periodic or continuous direct impingement spray of the salt solution over the 15-minute interval that ensures the test specimens are kept wet for the entire 15-minute interval. Avoid a high intensity (pressure) spray that may affect test results. (Note 5) Both direct solution displacement and atomized spray are suitable for this method.
c. Air Atomized Fog Method—Applications of the salt solution to the test specimens by a 15-minute exposure to atomized fog provided the fog collection rate is 2 to 4 mL/h instead of 1 to 2 mL/h (collection rate as defined in ASTM D 1735). The use of this method requires that the collection rates be documented.

NOTE 1—“Either the $CaCl_2$ or $NaHCO_3$ material must be dissolved separately in DI water (Reference ASTM D 1193 Type IV) and then added to the solution of other materials. If all solid materials are added at the same time in a “dry” state, an insoluble precipitate may result. If a precipitate forms and a spray application is used to apply the solution, it may be necessary to remove the precipitate to avoid clogging of nozzles (i.e., filter or siphon solution). Any filter media used must be inert to the solution being used. A 20 to 100 micron cotton or nylon mesh filter would be suitable. Do not attempt to dissolve the precipitate by adding acid.

NOTE 2—Measure and record pH of the salt solution prior to the start of test and on a weekly basis thereafter (Reference ASTM E 70-90). Do not attempt to adjust the pH with any form of buffers.

NOTE 3—The majority of the development of this specification was performed using the immersion method of salt solution application. This method was used as the basis when comparing other methods of salt solution applications as well as other variables.

NOTE 4—A freshly prepared test solution will have a conductivity of 10 to 12 ms at 25 °C ± 2 °C. Measure and record the conductivity (in units of ms) of the salt solution after mixing, prior to the last amount being used, and as needed to ensure that the conductivity of the solution remains between 10 to 12 ms at 25 °C.

NOTE 5—Careful attention should be paid to the spray method to avoid a high intensity spray that may affect test results by removal of the corrosion product, removal of the coating or driving solution into the corrosion products.

It is recommended that the test solution be changed weekly and that agitation/stirring of the solution be done prior to the salt solution application.

5. Test Procedure

5.1 Test Cycle—The test cycle is outlined in Figure 1 (5 day/week – manual operation) and Figure 2 (7 day/week - automatic operation). It consists of three basic stages:

1. Humid Stage—50 °C and 100% Humidity, 6 h in duration,
2. Salt Application Stage—15 min duration conducted at ambient conditions
3. Dry Stage—60 °C and 50% RH, 17 h and 45 min in duration

The test cycle is repeated daily. Fully automatic cabinets have the option of running during the weekends or programming in a dry stage soak for the weekends (typically it would be desired to run on weekends and holidays to complete the test sooner). An exception to this rule would be if comparisons to other laboratories who do not have fully automatic capabilities is desired (for manual operations, the weekend exposure is typically maintained at dry stage conditions unless 7 day operations are available). Total test duration and weekend conditions must be documented in the test results. If two or more laboratories will be conducting tests on similar parts, it is recommended that a constant/common weekend condition be defined before testing begins.

Ramp time between the salt application stage (2) and dry stage (3) are part of the dry stage time. Similarly, ramp time between the dry stage (3) and humid stage (1) are part of the humid stage. Ramp times should be documented for each test set-up.

For cosmetic corrosion evaluations of coatings susceptible to damage, test samples will be scribed prior to exposure (Reference ASTM D 1654). Scribe length should be a minimum of 2 in. Scribe creepback measurements are to be taken at predetermined intervals depending on the level of corrosion resistance desired. Scribe orientation, on the specimen, must be specified and documented (for typical flat panel specimens, it is recommended that panels be oriented 15 degrees from the vertical such that no one panel shadows another and that the scribe line be made in a diagonal across the panel face).

5.2 Test Duration—Typically, SAE J2334 is conducted for a minimum of 60 cycles when evaluating coated products. Longer durations may be required to observe performance differences in the heavier weight metallic precoats. Different test durations may be appropriate based on other materials, corrosion mechanisms of interest, or past history.

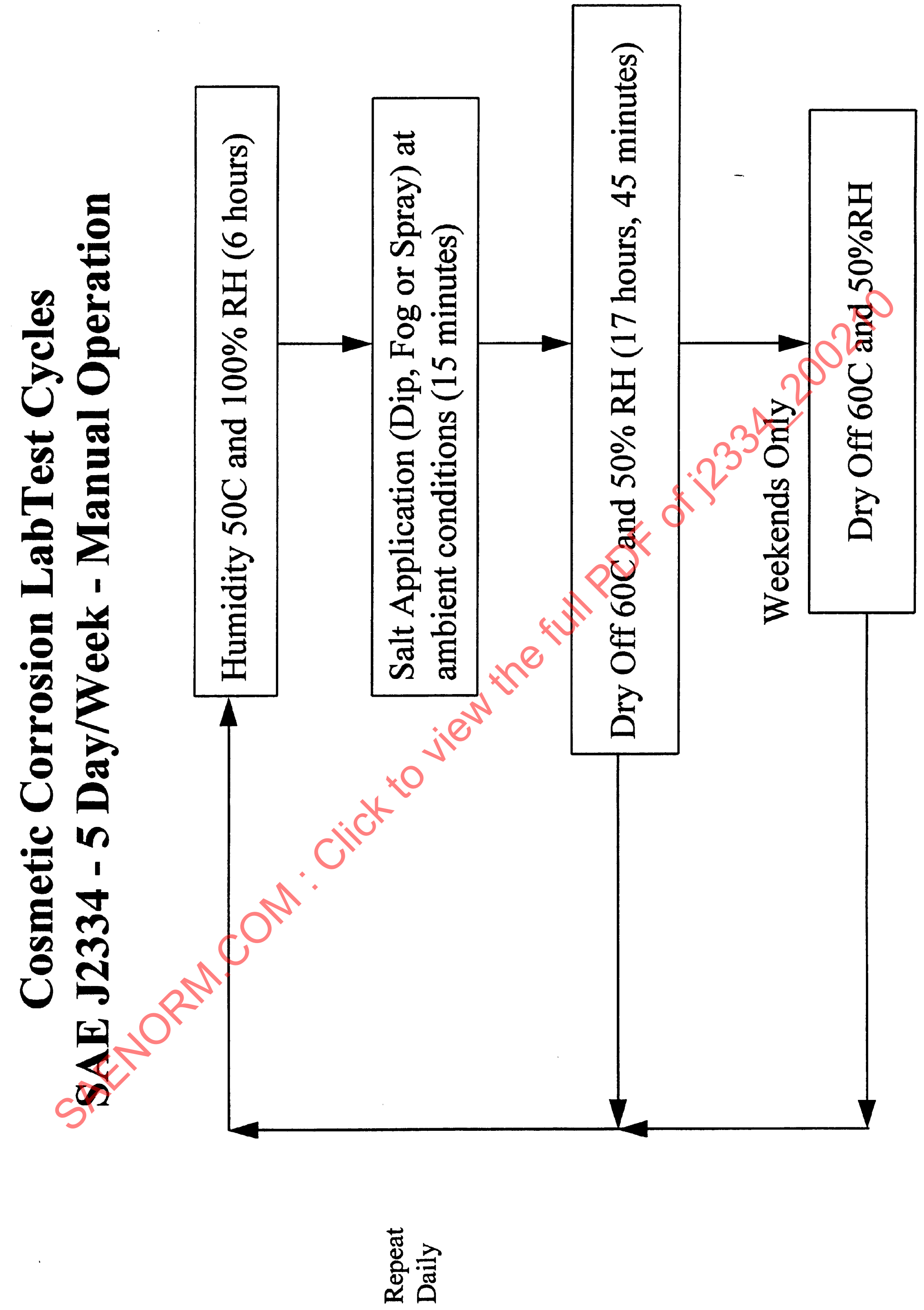

FIGURE 1—COSMETIC CORROSION LAB TEST CYCLES—5 DAY/WEEK—MANUAL OPERATION

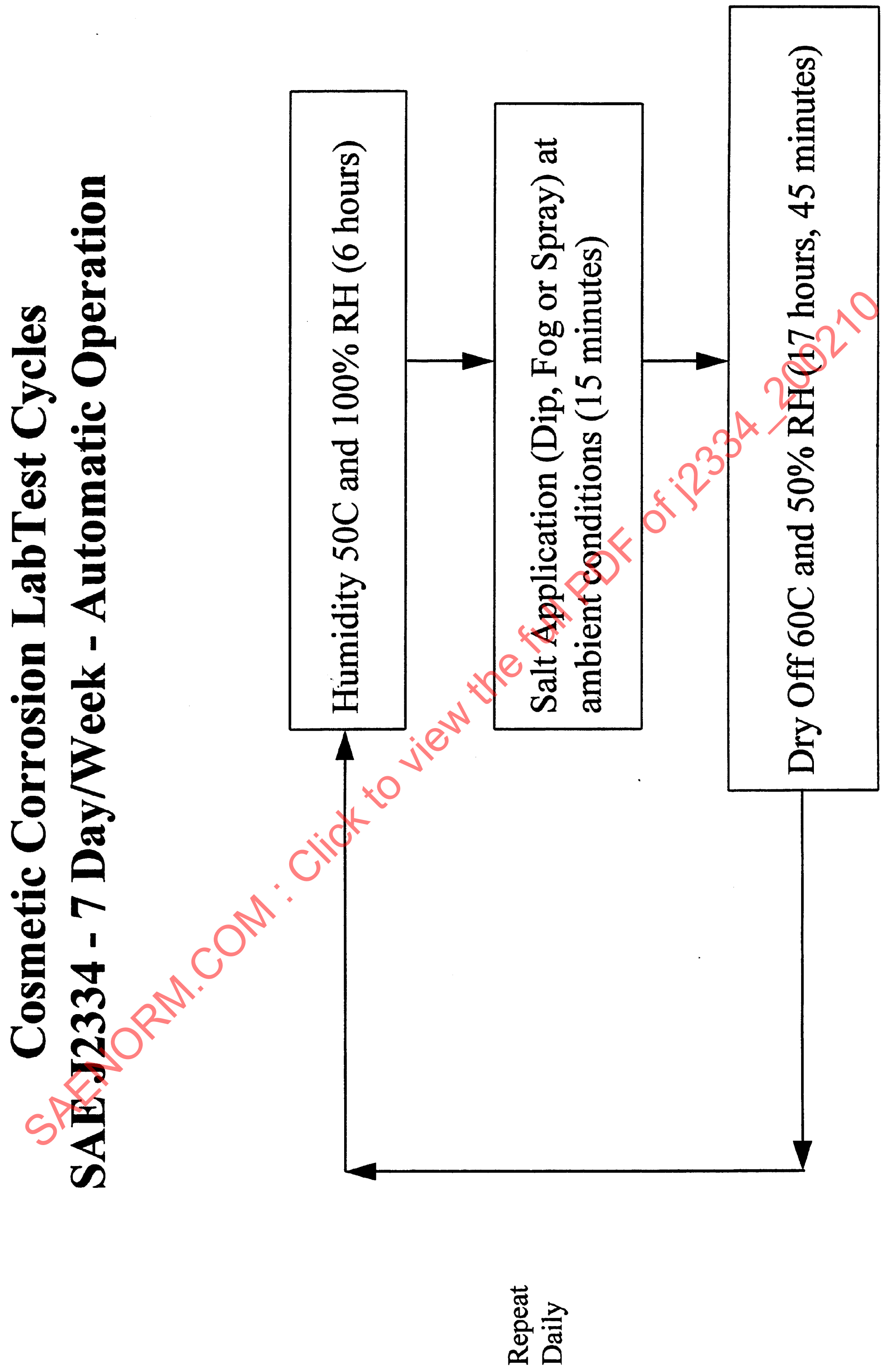

FIGURE 2—COSMETIC CORROSION LAB TEST CYCLES—7 DAY/WEEK—AUTOMATIC OPERATION

5.3 **Coupon Monitoring—**The testing process will be monitored with bare steel corrosion coupons.

a. Corrosion coupons generally consist of 25.4 mm by 50.8 mm pieces of bare sheet metal which serve to monitor the corrosivity of the test environment during the test. The sheet metal coupon will always include low-carbon cold rolled steel sheet (AISI 1006-1010), and may also include other bare metals, such as zinc.
b. Each coupon shall be permanently identified by stamping a number onto the surface.
c. Corrosion coupons shall be thoroughly cleaned to remove all forming and storage oils/lubes with a commercially available degreaser followed by a methanol rinse. Then the mass in milligrams shall be recorded and retained for future reference.
d. The coupons shall be secured to an aluminum or nonmetallic coupon rack. The coupons shall be electrically isolated from the rack by using fasteners and washers made from a non-black plastic material, preferably nylon.
e. Allow a minimum 5 mm spacing between the coupons and the rack surface. All coupons shall be secured at a maximum 15 degrees from vertical and must not contact each other.
f. The coupon rack shall be placed in the general vicinity of the samples being tested, such that the coupons receive the same environmental exposure.
g. Coupons shall be removed and analyzed after a predetermined number of cycles throughout the test to monitor corrosion. To analyze coupons, remove 1 coupon from each end of the rack and prepare for weighing and mass loss determination. Insure enough coupons are exposed in the test so monitoring frequency can be accomplished. Additional unexposed coupons can be added throughout the test to obtain interval data in addition to cumulative data.
h. Before weighing, clean the coupons using a mild “sand blast” (preferably glass beads) to remove all corrosion by-products from the coupon surface. An alternative/equivalent cleaning method, using a chemical process, is described in ASTM G 1. Once clean, wipe the coupons with methanol and weigh to determine the coupon mass loss using Equation 1:

$$\text{Mass Loss} = (\text{Initial Mass}) - (\text{End-of-Exposure Mass}) \qquad \text{(Eq. 1)}$$

Corrosion losses may also be expressed in term of average corrosion rates from the mass loss, coupon area, test duration, and metal density by use of the calculation described in ASTM G 1.

6. Data Reporting

6.1 **Coupons—**Coupon mass loss values are to be recorded after each set of a predetermined number of cycles (typically, every 20 cycles). This will be a cumulative value. Additional unexposed coupons can be installed and removed after the next set of cycles to obtain interval coupon data if desired.

6.2 **Test Samples—**The test samples will have scribe creepback values or corrosion rate measurements recorded at predetermined intervals (typically, 20 cycles – in a rinsed only condition). At end-of-test two sets of creepback values will be recorded (if coated samples are to be evaluated) one set in a rinsed only condition and one set after the scrape and tape process (Reference 1989 SAE Automotive Corrosion and Prevention Conference P228, pages 144-5, see 2.1.4 (4)).

As a guideline, scribe creepback measurements of average, maximum, and minimum (total width) will be recorded.

6.2.1 BY DEFINITION

a. Total Width Creepback—A measurement of the distance between the unaffected paint film areas, in millimeters, on each side of the scribed line (measured across and perpendicular to the scribe line). (Loss of adhesion between paint film and substrate).
b. Average—The mean of a set of measurements of Total Width Creepback, at points spaced equidistant apart centered on the scribed line.
c. Maximum—A measurement of the Total Width Creepback at the point with the most extensive adhesion loss, discounting the areas at the ends of the scribed line.
d. Minimum—A measurement of the Total Width Creepback at the point with the least extensive adhesion loss, discounting the areas at the ends of the scribed line.

6.3 Test Equipment—Test equipment used shall be documented and include the following information:

If multiple cabinets are used to conduct the test, the following information must be recorded for each cabinet.

a. Cabinet Manufacturer/Model
b. Humidity
c. Temperature
d. Humidification Process
e. De-humidification Process
f. Heating Process
g. Cooling Process
h. Air Circulation Process
i. Size
j. Capacity
k. Calibration Process
l. Frequency of Calibration
m. Ramp Time Between Stages

6.3.1 SOLUTION INFORMATION:

a. Frequency of Salt Solution Changes (recommend weekly or sooner if contamination is a suspected concern)
b. Method of Salt Application
c. pH Measurement Method
d. If an Air Atomized Fog is chosen, then collection rates must be taken and documented.
e. Measure and record the conductivity (in units of ms) of the salt solution after mixing, prior to the last amount being used, and as needed to ensure that the conductivity of the solution remains within range. A freshly prepared test solution will have a conductivity of 10 to 12 ms at 25 °C ± 2 °C.

If a recorder is in use, a representative cycle profile 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.

PREPARED BY THE SAE AUTOMOTIVE CORROSION AND PREVENTION COMMITTEE