ACCELERATED CORROSION TEST

GM9540P

1 SCOPE. 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 duration can be individually tailored to achieve any desired level of corrosion exposure.

Also, synergistic effects due to temperature, mechanical and electrical cycling can be comprehended by this test. See Appendix A for typical modifications.

NOTE: Test durations A and B can be used as both QC tests and validation tests depending on the purpose of the test. Test durations C and D or any modified test are to be used for validation and development purposes.

1.1 The test method is comprised of 1.25% (0.9% sodium chloride, 0.1% calcium chloride and 0.25% sodium bicarbonate) salt mist applications coupled with high temperature and high humidity and moderately high temperature dry off. It requires a 16 h work day or an automatic cycling test chamber.

IMPORTANT: Engineering drawings and material specifications that reference this test procedure must specify the test duration, (A, B, C or D) or the number of test cycles as indicated in Table 1. (Example, GM9540P, Test Duration B.) In addition, the criteria for making pass/fail determinations must be specified. Test durations A and B can be used for quality control and validation procedures as appropriate. Longer test durations (C and D) and tests involving modifications are to be used for validation purposes only.

TABLE 1 - CYCLES (APPROXIMATE) FOR TARGET MASS LOSS

	Test Duration			
	A	B	C	D
Test Method	8 Cycles	16 Cycles	40 Cycles	80 Cycles
Coupons Required (mm)	2	4	10	20

TABLE 2 - MASS LOSS TARGET RANGES, mg*(AT THE END OF TEST)

Initial Coupon Thickness		Test Duration			
mm	in	A	B	C	D
0.79	1/32	828-1228	1496-1896	3210-3810	6038-6638
1.59	1/16	874-1274	1574-1974	3378-3978	6345-6945
3.18	1/8	965-1375	1731-2131	3712-4312	6957-7557
6.35	1/4	1147-1547	2043-2443	4379-4979	8178-8778

* These mass loss values correspond to the test duration requirements listed in Table 1 above and are applicable to the standard test procedure only. Modifications to the test may or may not attain equivalent levels of mass loss.

NOTE 1: A cycle is made up of the daily events or test inputs prescribed in Table 4. A cycle normally requires 1 day to complete. The test duration is dictated by the number of test cycles.

NOTE 2: A phase is made up of a predetermined number of cycles, 8 cycles constitute 1 phase.

NOTE 3: The coupon mass loss values shown in Table 2 are used to verify that the correct amount of corrosion has been produced by the test.

2 REFERENCED STANDARDS.

GM4465P GM9508P
GM9102P ASTM B117

3 EQUIPMENT AND TEST MATERIAL.

3.1 TEST EQUIPMENT.

3.1.1 Fog Humidity Cabinet. The humidity cabinet shall be as specified by GM4465P and Table 3. (Water fog or visible water droplets on parts - continuous after equilibrium is reached.)

3.1.2 Salt Mist Application. The salt mist solution shall be as specified in Table 3. The solution shall be sprayed as a mist (for example, from a plastic bottle onto the test samples and coupons). The spray nozzle shall be such that the salt solution is atomized into a mist as required. A siphon spray powered by oil-free regulated air or a hand operated pump spray may also be used. The quantity of spray applied should be sufficient to rinse away any salt accumulation left from previous sprays. (Test samples and coupons shall be thoroughly wet/dripping.)

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3.1.3 Dryoff Environment. The dryoff environment area shall be maintained with sufficient air circulation to prevent temperature stratification, and also allow thorough drying of the material. The temperature and humidity conditions are shown in Table 3.

TABLE 3 - TEST PARAMETERS

Test Equipment	Test Method
Fog Humidity Cabinet Temperature	GM4465P @ 49 ± 2°C
Salt Solution	
Sodium Chloride, %	0.9**
Calcium Chloride, %	0.1
$NaHCO_3$ Concentration, %	0.25
Salt Solution pH	6-9
Dryoff Environment	
Temperature	60 ± 2°C
Humidity	< 30% RH
Ambient Temperature	25 ± 2°C
Ambient Humidity	40-50% RH

** For spray solution, 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.

3.2 TEST MATERIALS.

3.2.1 Corrosion Coupons. Coupons consist of 25.4 mm wide x 50.8 mm long pieces of bar AISI 1006-1010 steel. Four (4) coupon thicknesses are available as shown in Table 2. The coupons serve to monitor the average general bare steel corrosion produced by the test environment.

3.2.1.1 Coupon thickness selection will be dictated by individual test needs. However, thicker coupon sizes should be used for tests with long durations.

NOTE: Do not intermix different coupon thickness on the same coupon rack.

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

4 TEST PROCEDURE.

4.1 COUPON/TEST SAMPLE PREPARATION.

4.1.1 Each coupon shall be permanently identified by stamping numbers onto the surface.

4.1.2 Corrosion coupons can be cleaned with methanol or acetone solution and accurately weighed prior to use. The weight, in milligrams (mg), shall be recorded and retained for future reference.

NOTE: 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.

4.2 COUPON RACK PREPARATION. Prior to start of test, prepare the coupon rack with sufficient coupons to monitor the test.

4.2.1 The coupons shall be secured to an aluminum or nonmetallic coupon rack with fasteners as shown in Figure 1. The bolt, nut and washers shall be made from a non black plastic material, preferably nylon. Figure 1 shows a completed coupon rack configuration. The number of coupons required for different test durations are shown in Table 1.

4.2.2 The exact location of each coupon on the rack shall be identified and recorded using the prestamped numbers for reference as illustrated in Figure 1.

4.2.3 Allow a minimum 5 mm spacing between the coupons and the rack surface. All coupons shall be secured at most 15° from vertical and must not contact each other.

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

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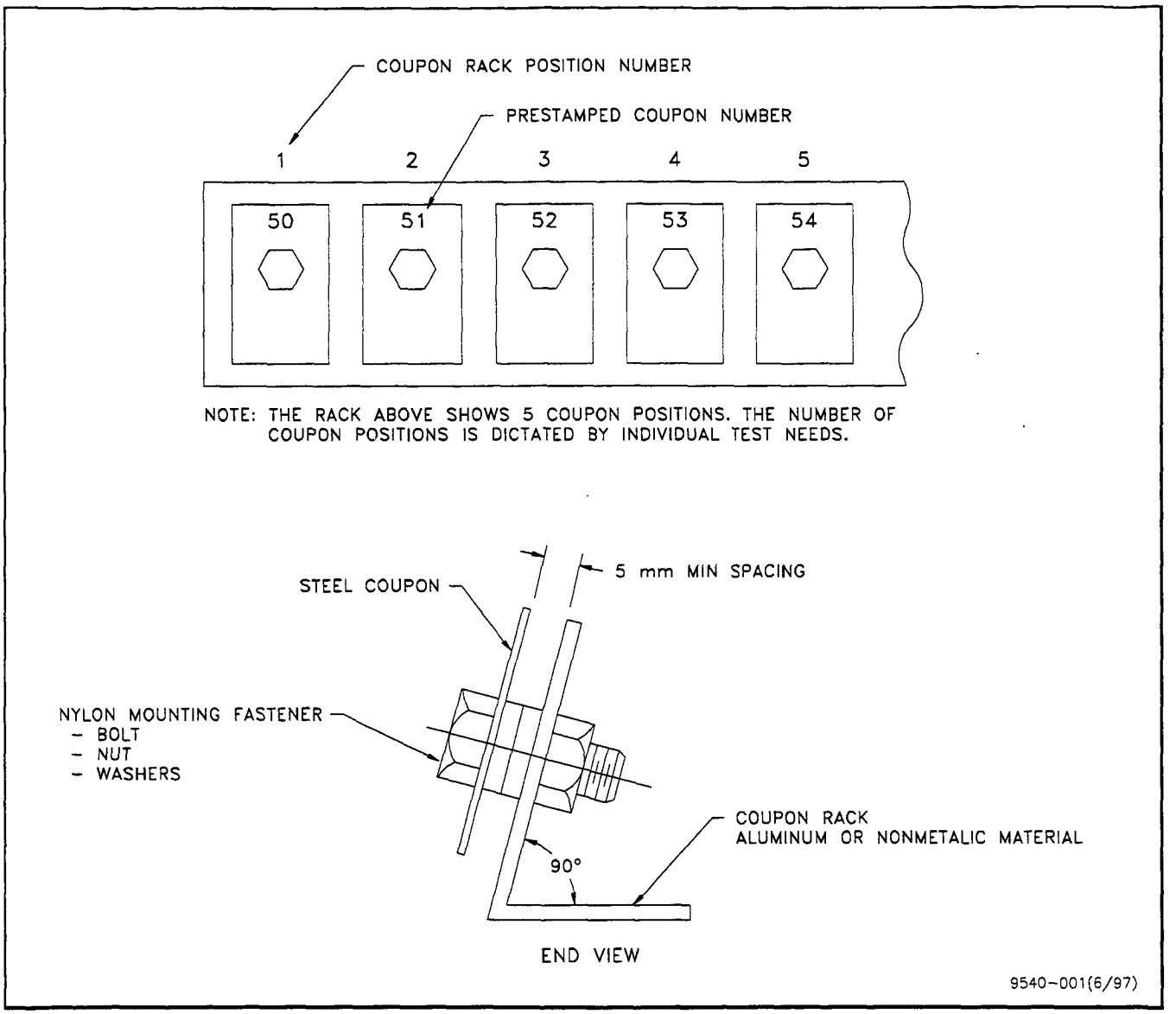

FIGURE 1 - COUPON RACK ASSEMBLY

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4.3 TEST METHOD. See Table 4 for the steps that comprise the test method. Repeat the cycle daily as necessary until the test duration requirements are met. At the option of the test requester, the test can be continued throughout weekends to decrease the over all test time.

4.3.1 For each salt mist application, use the sprayer to mist the samples and coupons until all areas are thoroughly wet. The mist application occurs while the samples and coupons are in the ambient environment. The times in Table 4 for the salt mist application can be varied by ± 30 minutes, as long as the parts are visibly dry before each application.

TABLE 4 - TEST METHOD

Time*	Event
6:00 am	Salt mist application (in ambient env)
7:30 am	Salt mist application (in ambient env)
9:00 am	Salt mist application (in ambient env)
10:30 am	Salt mist application (in ambient env)
2:00 pm	8 h humidity cabinet exposure including 1 h ramp to wet conditions
10:00 pm	8 h dry environmental exposure including 3 h ramp to dry conditions
Weekends	Ambient environment

*Times are shown for example purposes only. The test can be started at any time with the understanding that 24 h constitutes 1 cycle.
NOTE: If gravelometer exposure is required, test samples (not coupons) may be exposed to gravelometer testing per GM9508P before or during exposure.
NOTE: If specimen scribing is required, on either test panels or parts, follow the methods described in GM9102P. 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 testor.

4.4 TEST ACCELERATION. Humidity ramp times between the ambient and wet condition and between the wet and dry conditions are critical to test acceleration (this is because corrosion rates are highest during this transition period). 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. If a test is conducted with ramp times different than described above, the number of cycles to reach coupon mass loss targets may increase or decrease. 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 each phase throughout the test to monitor the corrosion. To analyze coupons remove 1 coupon from each end of the rack and prepare for weighing and mass loss determination. (EXAMPLE: For a B duration, 2 coupons are removed and analyzed after 8 cycles, and another 2 coupons after 16 cycles.)

4.5.1 Before weighing, clean the coupons using a mild sand 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-Phase Mass)

4.5.2 Compare the actual mass loss to the targeted values. Refer to Table 2 for targeted mass loss values, in milligrams, for various test durations as a function of the coupon's original thickness.

NOTE: Coupon mass loss targets for every phase are not included in Table 2. To check test progress and assure that the test is being run correctly, assume a linear corrosion rate. Thus, if the test is 40% complete the coupon mass loss value should be approximately 40% of the end-of-test targeted range.

NOTE: If the actual mass loss does not coincide with the targeted values listed in Table 2 the test should be repeated. Also, the reasons why the targeted value(s) was not obtained should be investigated and corrected before resuming the test.

4.6 INSPECTION. The test sample(s) shall be inspected for corrosion and photographed at the end of predetermined cycles. If plastic materials are being tested any discoloration or degradation and/or adhesive bond failure (delamination) shall be noted and recorded.

4.7 END OF TEST. At the end of test the samples shall be rinsed with fresh tap water and allowed to dry before evaluating. One (1) test cycle is equal to 24 h, 1 phase is equal to 8 cycles.

5 REPORT. In addition to the sample data and test results, reports must indicate the total number of cycles run, any modifications to the test (see Appendix A), the Equipment and Test Record Form (Appendix B) and should include photographic documentation and the coupon mass loss values.

6 SAFETY. This method 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 this method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 GENERAL INFORMATION. This standard was written by a task group and approved by the Letter Ballot Committee in February 1991. The latest revisions include: This procedure supersedes any old procedures that may have referenced an "A" or "B" Test Method (Method A is eliminated).

Rev	Date	Description
C	9/97	Editorial Revision - Table 2, Table 3 and A4.1 - 4.9 footnotes
D	12/97	Editorial Revision - A 4.4 Option Number

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APPENDIX A

A1 MODIFICATIONS. These procedure modifications 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 modifications, please contact either the platform materials group, NAO Materials and Fastening Engineering or the NAO Validation/QRD Center - Corrosion Engineering Group.

A2 TEST. The test is generally made up of 3 shifts: An *Ambient Shift* (8 h) in which salt sprays are conducted, a *Wet Shift* (8 h) in which parts are soaked at 49°C (120°F) and 100% RH, and a *Dry shift* (8 h) in which parts are soaked at 60°C (140°F) and ≤ 30% RH.

A2.1 AMBIENT SHIFT. The ambient shift can be modified to include additional test inputs such as dust, grit sprays, mechanical cycling, electrical cycling, thermal inputs, gravelometer and acid rain spray.

A2.2 WET SHIFT. Typically no modifications of this shift.

A2.3 DRY SHIFT. Typically no modifications of this shift.

A3 TEST SPECIMEN. If possible, mount test specimens in a production representative orientation simulating on-vehicle inputs (e.g., puddling of fluids, shielding of splash, wicking of fluids, etc.).

A4 EXAMPLES OF MODIFICATIONS.

A4.1 OPTION I - A/C COMPRESSOR TEST MODIFICATIONS.

Ambient Soak (8 h).
1 salt spray on 1st cycle - compressor running
1 grit spray on seventh cycle - compressors static
1.5 h of compressor run time (cycling 12 s on/3 s off)
Wet Soak 120°F/100% RH (8 h)
Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.2 OPTION II - TRANSMISSION OIL COOLER LINE TEST MODIFICATIONS.

Oven Soak 250°F (2 h).
Ambient Soak (6 h)
4 salt sprays - starting at the end of the 2nd h of the ambient soak, spaced 1 h apart
Wet Soak 120°F/100% RH (8 h)
Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.3 OPTION III - SIDE DOOR LATCHES AND HOOD LATCHES (ASSUMES NO WEATHERSEAL PROTECTION) TEST MODIFICATIONS.

Ambient Soak (8 h).
1 salt spray *per cycle*
1 dust application at the beginning of each phase (see Appendix C)
Wet Soak 120°F/100% RH (8 h)
Dry Soak 140°F/≤ 30% RH (8 h)
Fresh water rinse at the end of each phase

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.4 OPTION IV - DOOR HINGES, HOOD HINGES, FUEL FILER DOOR HARDWARE, AND DECKLID HINGES (ASSUMES NO WEATHERSEAL PROTECTION) TEST MODIFICATIONS

Ambient Soak (8 h).
1 salt spray *per cycle*
1 dust application at the beginning of each phase (see Appendix C)
Wet Soak 120°F/100% RH (8 h)
Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.5 OPTION V - KEY CYLINDERS TEST MODIFICATIONS.

Ambient Soak (8 h).
1 *hose* salt spray per cycle (see Appendix D)
1 dust application (both sides of test sample in fixture) at the beginning of each phase (see Appendix C)
Wet Soak 120°F/100% RH (8 h)
Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.6 OPTION VI - DECKLID LATCH (also applicable to other latches which have weatherseal protection) and DECKLID HINGES (with weatherseal protection) test modifications.

Ambient Soak (8 h).
1 salt spray *per phase*
Wet Soak 120°F/100% RH (8 h)
Dry Soak 140°F/± 30% RH (8 h)

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1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.7 OPTION VII - DOOR DETENT TEST MODIFICATIONS.

Use Option IV - for door detents without weatherseal protection

Use Option VI - for door detents with weatherseal protection

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.8 OPTION VIII - DOOR CAVITY HARDWARE TEST MODIFICATIONS.

Ambient Soak (8 h).

1 salt spray per cycle

1 dust application at the beginning of phases 0, 3, 6 and 9 (see Appendix C)

Wet Soak 120°F/100% RH (8 h)

Dry Soak 140°F/≤ 30% RH (8 h)

Fresh water rinse at the end of each phase

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.9 OPTION IX- EXHAUST MANIFOLD, FLEX COUPLING TEST MODIFICATIONS.

Oven Soak 900°F (4 h)

Ambient Soak (4 h).

4 salt sprays starting at the end of the 1st h of the ambient soak period spaced 1 h apart

Wet Soak 120°F/100% RH (8 h)

Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.10 OPTION X - MUFFLER/TAILPIPE TEST MODIFICATIONS.

Oven Soak 400-500°F (4 h)

Ambient Soak (4 h).

4 salt sprays starting at the end of the 1st h of the ambient soak period spaced 1 h apart

Wet Soak 120°F/100% RH (8 h)

Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Expected test duration to evaluate functional corrosion is 10 phases.

A4.11 OPTION XI - INTERIOR (PASSENGER COMPARTMENT) CORROSION ENVIRONMENT TEST MODIFICATIONS.

Ambient Soak (8 h).

Salt spray frequency options

1 only at beginning of 1st cycle if under dash (mid to high mount) location

1 each at beginning of 1st, 5th, and 12th cycles floorpan (low mount) location

Wet Soak 120°F/100% RH (8 h)

Dry Soak 140°F/≤ 30% RH (8 h)

1 test cycle is equal to 24 h, 1 phase is equal to 8 cycles. Typical test duration is 4 cycles for under dash (mid to high mount) locations and 12 cycles for floorpan (low mount) locations which approximately equals 10 *years* cosmetic corrosion exposure.

A5 ADDITIONAL OPTIONS. Additional options can be customized to specific components or subsystems to increase the ability to conduct validation or development testing. Please see the platform materials engineer, NAO Materials and Fastening Group or NAO Validation/QRD Center - Corrosion Engineering Group for assistance. Any option changes not called out specifically in this Appendix must be included on the engineering drawing.

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APPENDIX B
EQUIPMENT AND TEST RECORD FORM

B1 TEST EQUIPMENT. Test equipment used shall be documented and include the following information:

Model
Temperature Range
Heating Process
Cooling Process
Circulation Process
pH
Conductivity of salt solution
Collection rate (recommend 4-8 mL/h/80 cm^2 ± 0.5 mL/min)
Method of salt application
Humidity Range
Humidification Process
Dehumidification Process
Type of Control
Recorder Y/N, if yes, what is recorded?
Size/Capacity
Calibration Process
Calibration Frequency/Last Occurrence
Frequency of Changes of the Salt Solution (recommend weekly)
Volume of Salt Immersion Tank
Average Ambient Temperature and Range During Test

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 states conditions.

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APPENDIX C
DUST APPLICATION/SPECIFICATION

C1 DUST TYPE. Arizona Dust, typically fine grade, as procured from Powder Technology Incorporated of Burnsville, Minnesota, (612) 894-8737 or as prepared by Delphi-E (P/N 1543094) with the following particle size distribution by volume (measured with an L&N microtrac analyzer as referenced on the product label):

Micrometers	% Less Than
5.5	38 ± 3
11	54 ± 3
22	71 ± 3
44	89 ± 3
176	100

C2 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 the air line). Garden dusters with an 8 mm diameter hole for dust application are recommended to achieve the appropriate level of dust application. Garden dusters from the following manufacturers could be modified: Hudson Sprayer, Hudson Mfg. Co., Chicago, IL or R.L. Corporation, Lowell, MI (a division of Root-Lowell Manufacturing).

C3 DUST APPLICATION. Using 25 to 30 psi of air line pressure, apply a dust mist for approximately 1 s such that 1 g ± 0.25 g of dust is applied to the part. Keep the applicator agitated to ensure proper dust application (agitate/shake duster between applications.)

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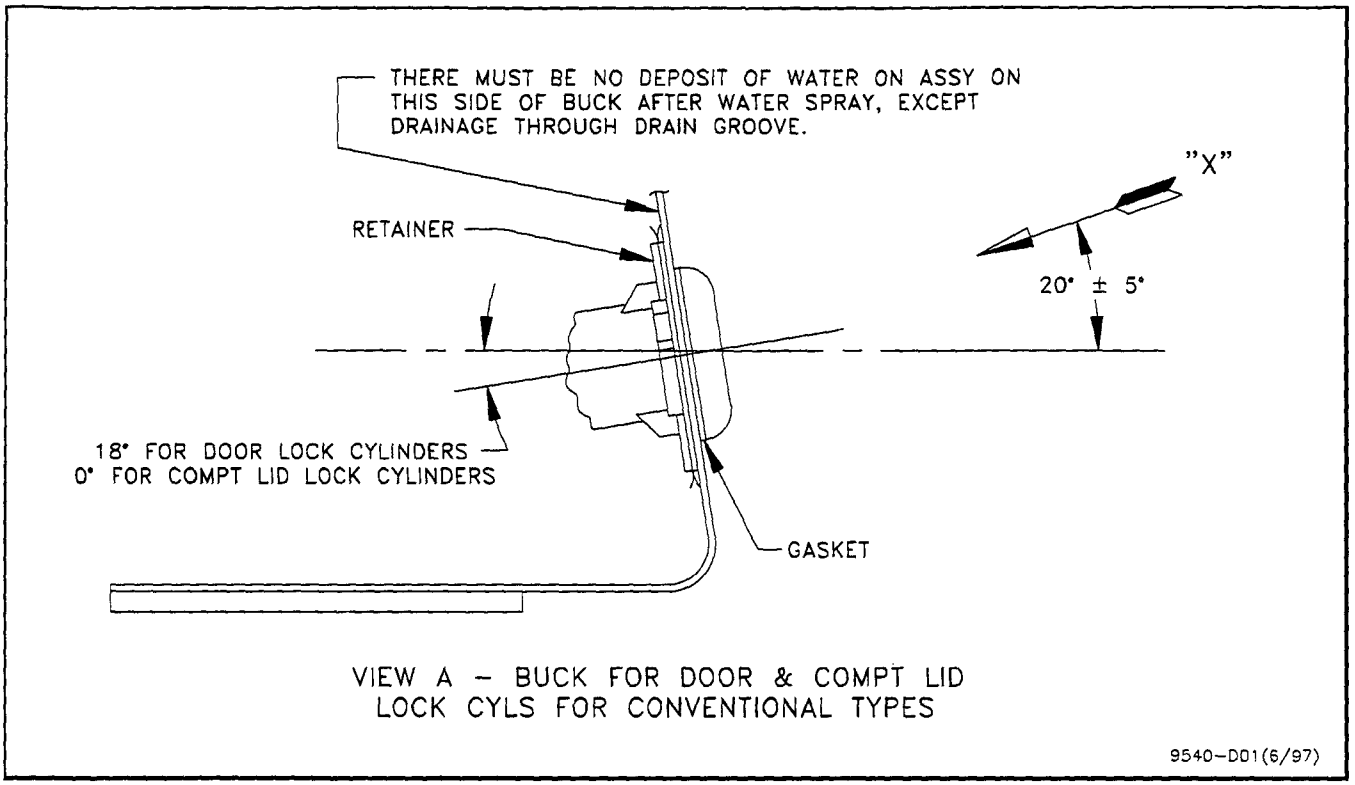

FIGURE 1D - BODY TEST POSITION FOR DOOR AND REAR COMPARTMENT LOCK CYLINDER